JOURNAL OF

THE INSTITUTE OF PETROLEUM

FOUNDED 1913 + INCORPORATED 1914

Vol. 37 DECEMBER 1951 No. 336

Contents

Our Unproduced Reserves; What are they?
By Morris Muskat

Influence of CS_2 on Octane Number and Lead Susceptibility
By G. E. Mapstone and J. S. Durham

The Expansion of Vertical Cylinders Under Liquid Head
By Peter Kerr

Indexes to Vol. 37

Abstracts Book Reviews New Members

Published by the Institute of Petroleum
Address: Manson House, 26 Portland Place, London, W.1
Telephone No.: LANgham 2250
Telegraphic Address: Instpetech, Wesdo, London
Printed in Great Britain by Richard Clay and Company, Ltd., Bungay, Suffolk
Price 10s. 0d. Annual Subscription £4 14s. 6d. (Post Free)

COUNCIL, 1951–52

PRESIDENT

C. A. P. Southwell, M.C., B.Sc.

PAST-PRESIDENTS

Sir Andrew Agnew, C.B.E.
S. J. M. Auld, O.B.E., M.C., D.Sc.
J. S. S. Brame, C.B.E., F.R.I.C.
T. Dewhurst, A.R.C.S.
A. E. Dunstan, D.Sc., F.R.I.C.
E. A. Evans, M.I.Mech.E., F.R.I.C.
F. H. Garner, O.B.E., Ph.D., F.R.I.C.

VICE-PRESIDENTS

M. A. L. Banks, B.Sc., F.R.I.C.
E. J. Dunstan, M.Sc.
E. B. Evans, M.Sc., Ph.D., F.R.I.C.
F. Morton, Ph.D., F.R.I.C.
J. S. Parker, M.A., B.Sc.
H. C. Tett, B.Sc., D.I.C.

MEMBERS OF COUNCIL

W. S. Ault, B.A.
V. Biske, LL.M., B.Sc., F.R.I.C.
C. D. Brewer, M.I.Mech.E.
F. L. Garton, M.A., B.Sc.
H. S. Gibson, C.B.E., M.A., M.I.Mech.E.
J. G. Hancock
E. LeQ. Herbert, B.Sc., F.R.I.C.
H. Hyams
J. A. Oriel, C.B.E., M.C., M.A.
H. E. F. Pracy, B.A.
D. L. Samuel, B.Sc., A.R.I.C.
G. H. Smith, Ph.D.
R. B. Southall
E. J. Sturgess, B.Sc.
O. F. Thompson, O.B.E.
G. H. Thornley, M.Sc.
H. de Wilde, M.Sc., M.I.Mech.E.
A. T. Wilford, B.Sc., F.R.I.C.
C. S. Windebank, B.Sc., M.S.

EX-OFFICIO

I. McCallum, B.Sc. Fawley Branch
N. E. F. Hitchcock, B.Sc. London Branch
H. H. Ballard. Northern Branch
W. M. Stirling, A.H-W.C., A.M.I.E.E. Scottish Branch
E. J. Horley. South Wales Branch
J. C. Cragg, B.Sc., F.R.I.C. Stanlow Branch

HONORARY SECRETARY: C. Chilvers, B.Sc., F.R.I.C.

HONORARY TREASURER: G. H. Coxon

HONORARY EDITOR: F. H. Garner, O.B.E., Ph.D., F.R.I.C.

HONORARY ASSOCIATE EDITOR: E. B. Evans, M.Sc., Ph.D., F.R.I.C.

EDITOR: George Sell

GENERAL SECRETARY: D. A. Hough, A.I.A.C.

TECHNICAL SECRETARY: Peter Kerr, M.A., B.Sc., Hon.F.H-W.C., F.R.I.C.

HONORARY SECRETARIES OF BRANCHES

Fawley Branch: I. McCallum, B.Sc., "Treside," New Road, Hythe, Southampton.

London Branch: H. G. Spence, B.Sc., c/o Shell Petroleum Co. Ltd., St. Helen's Court, Great St. Helen's, London, E.C.3.

Northern Branch: G. M. Davies, c/o Esso Petroleum Co. Ltd., Mode Wheel Installations, Trafford Wharf Road, Manchester 17.

Scottish Branch: W. M. Stirling, A.H-W.C., A.M.I.E.E., Scottish Oils Ltd., Middleton Hall, Uphall, Broxburn, W. Lothian.

South Wales Branch: E. J. Horley, National Oil Refineries Ltd., Llandarcy, Glam.

Stanlow Branch: V. Biske, B.Sc., LL.M., F.R.I.C., Lobitos Oilfields Ltd., The Refinery, Ellesmere Port, Cheshire.

Trinidad Branch: F. R. Buck, M.A., B.Sc., c/o Trinidad Leaseholds Ltd., Pointe-à-Pierre, Trinidad, B.W.I.

THE INSTITUTE OF PETROLEUM

An Ordinary General Meeting of the Institute of Petroleum was held at Manson House, 26 Portland Place, London, W.1, on Wednesday, September 19, 1951, the President, Mr C. A. P. Southwell, M.C., B.Sc., in the Chair.

The Minutes of the Ordinary General Meeting held on May 9, 1951, were read, confirmed, and signed.

The President, expressing his great pleasure in introducing Dr M. Muskat, said :

Dr Muskat is so well known, both in the American and British oil industries, that there is really no need for an introduction. Those of us in the petroleum industry who are interested in the scientific development of the oil reservoirs have to thank him for his published material, particularly the text-book on " The Physical Principles of Oil Production."

Dr Muskat is one of those scientific pioneers who is endeavouring to co-ordinate the knowledge and scientific data of the physical conditions of large reservoirs. We are very honoured, Dr Muskat, to have you here with us this evening under the ægis of the Institute of Petroleum so that our members in London may have this their first opportunity of hearing your views on this important phase of our industry.

We are also very glad to welcome here to-night, Professor Finch, President of the Physical Society. He is, of course, well known not only for his position in physical science but also for his exploits as a mountaineer. I feel sure that his mountaineering activities have given him a knowledge of geology which allied to his eminent position as a physicist brings him very near to problems of the petroleum industry.

The work on which Dr Muskat is engaged is an association of physical and geological sciences, and we are very glad to welcome Professor Pugh, Director of the Geological Survey of Great Britain. All of us in the petroleum industry owe so much to our geological friends because it is they who enable us to locate the raw material on which the life of the industry depends.

The following paper was then presented.

OUR UNPRODUCED RESERVES; WHAT ARE THEY?

By Morris Muskat *

The reference to " our " unproduced reserves in the title of this paper is intended to limit these comments to the situation in the United States. Evidently, the import and technical aspects of the question of reserves as pertaining to such a rapidly growing oil province as Western Canada, or to

* Gulf Oil Corporation, Pittsburgh, Pa.

the fascinating oil developments outside of continental North America, must be evaluated in a different light from that for the United States. Neither time nor understanding will permit the extension of these considerations into those areas.

It should also be pointed out that this paper will discuss *unproduced* rather than undiscovered reserves. The latter, which are an intriguing and indeed important subject for speculation, also lie beyond the scope of our discussion, which will be limited to the "proved" reserves of the United States.

The Problem

Before exploring the question as to what these unproduced reserves are, brief reference must be made to the question as to why bother with reserves

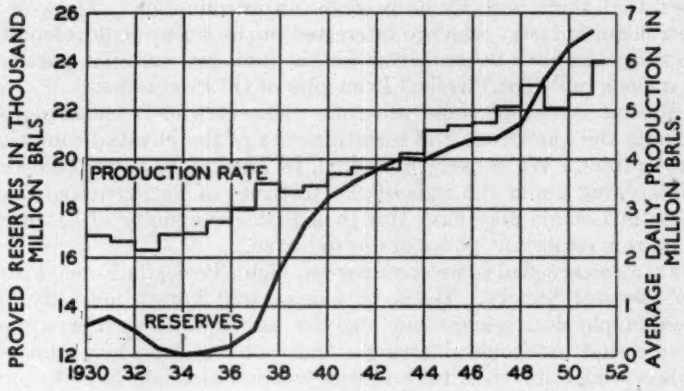


Fig. 1

U.S. CRUDE OIL RESERVES AND PRODUCTION RATES

at all. The answer, from a large-scale or national standpoint, is simply that the reserves give a measure of the current oil inventory. As an inventory, it is an index of business status, just like the number of cattle on a ranch or the tonnage of pipe in a warehouse. It indicates what is definitely known to be available for continuation of the oil-producing business, and more importantly for the millions of consumers of petroleum products in the form of fuels, lubricants, and petrochemicals. Of course, the reserves as estimated at any one time do not imply that the oil supply will be exhausted when the quantity then known to be available has been produced and consumed. Such would be true only under the fantastically unrealistic supposition that the oil industry would undertake a policy of absolute liquidation and devote no further effort or expense in search for additional and, at the moment, undiscovered oil reserves. That such would defy all precedent as well as reason is well demonstrated by the fact that as the result of the industry's continued search for oil an increasing reserves trend has been maintained for the last seventeen years, as shown in Fig. 1. That is, the new reserves discoveries and extensions have more than counterbalanced

the reserves liquidation, in spite of the fact that, with few exceptions, the annual average rates of production have increased throughout this period. It will be noted, incidentally, that the estimated reserves are 25,268 million barrels, as of January 1, 1951.

Since the reserves for the U.S. as a whole are the composite of those of individual fields and the different leases within these fields, they likewise are of importance for the various oil-producing companies operating in these fields. The total reserves for each company represent its current gross inventory of assured oil supply for its own future operations, not only as a producer of oil but also as a supplier for pipelines and refineries as well. Moreover, the reserves estimated for the separate producing properties are the key for their evaluation for purchase, sale, or trade. They also find application in determining the optimum economic well spacing, the desirability of installing artificial lift equipment, the probability of payout of workovers and recompletions, and the advisability of well abandonment. In evaluating fluid-injection proposals and in determining equities in unitization programmes the reserves again play an important role. These and still other applications of reserves data will make it clear why reserves estimation is one of the most important interpretative activities of the producing phase of the oil industry.

It may well be wondered why, if reference is simply to proved reserves in the United States, there is any serious question as to how large they are. We have no quarrel with the statistical analyses of the U.S. reserves discoveries and developments put forth by the distinguished American geologist Dr F. H. Lahee, Chairman of the API Reserves Committee, whose data, since 1935, have been plotted in Fig. 1. It is true, of course, as Dr Lahee has himself repeatedly emphasized, that the reserves discovered in the most recent years, such as 1948, 1949, and 1950, cannot be completely evaluated until the new fields have been fully explored and defined. These uncertainties are inherent in the nature of the problem. The reserves estimates are continually refined and improved by adjustments made in succeeding years in the light of development information. Nor are we concerned here with the well-known observation that reserves estimates are basically numbers of limited precision. Even a most superficial understanding of the complexities of reservoir description and performance prediction will suffice to explain the inevitable uncertainties associated with reserves calculations.

What we do wish to discuss is the implication of the remark that the reported unproduced reserves are the anticipated recoveries by *present producing operations*. This qualification, too, has been clearly stated by Dr Lahee, and is not merely a hidden assumption. But it lies at the heart of the question as to what our unproduced reserves really are. Indeed, the reason for emphasizing the point that estimated reserves must be related to the anticipated manner of field operation is really the primary thesis of this discussion, namely, that the magnitude of oil recovery may be materially affected by the mode of reservoir development and operation. Such a proposition may now well seem axiomatic, and perhaps too elementary to warrant amplification, especially before such a forum of engineering progress as is the Institute of Petroleum. However, it was not always so during the development of the oil-producing industry, and recognition of the fact that

our views have changed since these early days may prepare us to anticipate still further revision in the years to come.

In developing this thesis it is proposed first to review the role which presently established improved engineering practices can play in increasing the magnitude of our unproduced reserves, and then, secondly, to indicate some of the possibilities which may develop as the result of recent and future research.

What Can Be Done To-day?

As is well known, the applied science of producing and understanding the performance of oil reservoirs to the end that maximum economic oil recovery may be derived therefrom has been termed in the U.S. "reservoir engineering." From virtual infancy this science has grown rapidly in the last twenty years to a complex body of principles, theories, procedures, and practices which even the specialists and experts find difficult to fully master, and the continuing progress in which they find even more troublesome to keep pace with. But through the maze of intricate specific developments, two basic principles stand out as fundamental; namely:—

(1) *each reservoir is a unique physical system demanding individual analysis and treatment in the light of its own peculiar characteristics; and*

(2) *the gross performance of and recovery from a reservoir are not expressions of an immutable pre-ordained history, but are dependent on the nature of its development and of the production practices imposed thereon. The corollary with respect to reserves of this latter proposition is self-evident.*

It is not proposed to discourse on the well-accepted concepts that by virtue of the availabilty of different types of energy for movement of oil through the porous rocks comprising oil reservoirs the physical mechanisms whereby oil is actually expelled from the reservoir rock may be either (1) the solution gas drive, (2) the water drive, and (3) the gravity drainage or gas-cap expansion drive, or combinations of them. What it is wished to emphasize, however, is that these generally give different types of production performance and different recoveries. And of still more importance is the fact that the degree to which they participate in the composite producing mechanism is determined by the mode of field operation, within limits imposed by the inherent reservoir characteristics.

To return then to a paraphrase of the original question. What really are the remaining recoverable reserves in a particular reservoir? By general agreement, if a numerical answer has already been given to this question, it will refer to the type of operation and production mechanism *currently* being practised. While that is a realistic basis of appraisal, does it represent the maximum which can be economically derived? Is the field operating by the generally less efficient solution gas drive mechanism? If so, could it be converted to a more efficient oil-expulsion process? Could effective gravity drainage be induced by redistributing the centres of withdrawal and restricting the total producing rates and possibly double the ultimate recovery, and hence double the currently estimated reserves?

Or is it possible and desirable to develop an effective water drive, again by control of the distribution and magnitude of the production, and in this manner also perhaps increase materially the as yet unproduced reserves. Conversely, if edgewaters are tending to channel through high permeability zones so as to drown out the wells and limit the recoveries, is it practicable to control or retard such water invasion and at least insure solution gas drive reserves?

In addition to the control of the rate and distribution of production, fluid injection is the other basic and well-established means for affecting reservoir performance and recovery. Even the sweep action alone of injected gas, together with the economic gains from high-pressure operation, may under favourable circumstances, increase the unproduced reserves by 50 to 75 per cent over solution gas drive reserves. In many cases, unitized pressure maintenance by crestal gas injection may transform the producing mechanism into an efficient gravity drainage drive and double the unproduced reserves as compared to competitive solution gas drive depletion. The injection of water to supplement the invasion from low capacity aquifers often also may serve to materially increase the reserves to be anticipated from unsupported depletion operations. Have these possibilities been fully applied in the particular field under consideration?

Percentagewise, the increases in unproduced reserves which may be achieved by successful secondary recovery operations in fields nearing the limits of profitability are generally very much greater than when fluid injection is applied early in the producing life. This, of course, does not at all imply an inherent advantage of delaying fluid injection. But it is pertinent to investigate the potentialities for major increases in future recovery of many of the older fields not previously subjected to fluid injection whose reserves have become negligible. These general observations are, of course, common knowledge in the engineering profession, and need no further elaboration here. But have they been given full consideration in evaluating the future production history of our hypothetical field?

As you might well expect, if these questions were directed to the operators of specific producing fields in the U.S., the answer in virtually all cases would doubtless be: "Yes, we are well aware of all these matters, have considered them thoroughly, and are applying all engineering practices which could economically increase the recovery from our particular field. The reserves we calculate for this field are the maximum obtainable." In a great many instances, such would be a well-founded reply. Indeed, in the majority of the important producing states, the regulatory bodies closely follow the producing operations, encourage conservation practices, and, when in their judgment flagrant violations occur, they enforce conservation measures. Such improved and more efficient production practices have also been sponsored by the Interstate Compact Commission. And throughout the U.S. the important producing companies, as a policy of enlightened self-interest together with their deep concern for the national welfare and security voluntarily and without governmental instigation control their operations and institute measures to insure maximum oil recovery. There is no need here to apologize for or attempt to defend the profound business integrity of the American oil industry.

In a statistical sense, however, it is certain that most Americans would

agree that not all that can be done has been done—that there is room for improvement, and that there will be improvement. Perhaps the most inspiring characteristic of the oil industry is its own self-criticism and constant striving for progress in recognition of the fact that perfection has not yet been attained.

One of the reasons why the achievement of maximum efficiency in oil recovery everywhere throughout the U.S. has been a difficult task is the remarkable growth in demand for petroleum in the last decade. The increasing demands for crude oil, which have led to a rise in production rate in the U.S. from 3,697,000 barrels a day in 1940 to an amount in excess of 6 million barrels a day in 1951, have resulted in a constant pressure for taking maximum safe withdrawals as compared to more deliberate programmes of experimentation and study to determine the actual optimum methods and rates of production in each individual reservoir. The industry has indeed very effectively eliminated deliberate waste and inefficiency in oil-recovery operations. But it has had to do so under the stress of maintaining producing rates almost up to the very point where waste would be sure to result.

Perhaps an even more difficult problem the industry has had to contend with has been the development of legal and engineering procedures for unitizing fields for fluid-injection operations. While from a technical standpoint unitization operations are obviously necessary for effectively conducting reservoir-wide fluid-injection projects, the consummation of unitization agreements is generally a chore which taxes the most painstaking and patient efforts of the engineering, legal, and management staffs of the companies involved. Although it may seem surprising, in view of the many years of thought and study devoted to the problem, the definition of "equity," upon which the distribution of participation must be based, has been established as yet neither by statute nor practice. To reconcile the divergent views as to equity generally entertained by the many diverse interests in the common reservoir is evidently a necessary preliminary to the development of unitization agreements. Although it is admittedly an extreme case, the situation is well illustrated by the recently completed * unitization for water flooding the Lake Centralia–Salem field. The 9500 productive acres were distributed among 218 separate leases, controlled by twenty-seven individual operators. And the royalty interests included some 2000 separate accounts, located in forty-four states and seven foreign countries. The justifiable pride of those who achieved unitization in this field can well be understood when it is observed that after two years of effort all but the operating interests in fifteen productive acres and all but 115 royalty accounts were induced to sign the unitization agreement.

Although the practice of strict secondary recovery operations by gas or water injection developed as independent or co-operative projects long before unitization and field-wide pressure maintenance received general acceptance, their total contributions in the form of increased reserves is still relatively small, except in the case of the older producing states such as Pennsylvania and New York. Moreover, the overall scale of fluid-injection operations in the major oil producing states is also as yet a minor factor in reserves

* Love, R. E., AIME Meeting, St. Louis, Mo., Feb. 1951.

development. For example: in Louisiana fluid injection is currently being applied to fifty-nine reservoirs in twenty-three fields, as compared to only two such projects prior to 1940—a gratifying growth indeed. Yet the estimated increase in recoverable reserves, due to these operations, is less than 5 per cent of the total reserves for the state. And the twenty-three fields involved represent only about 5 per cent of all those in the state.

Even without offering further evidence or detailed similar statistics for the other producing states, it is believed fair to state that, in spite of the very creditable progress which has been made in applying fluid injection for increased oil recovery, such operations as a whole have only begun to materially effect the reserves picture. On the other hand, by virtue of this very fact, and in the light of the continually expanding scale of fluid-injection activities, it may well be expected that currently estimated unproduced reserves will be substantially increased through such operations before the fields now producing are depleted and abandoned.

How much will this increase be? Of course that is not known, but by being totally unscientific a prediction can be ventured by the process of pyramiding guesses. Statistics indicate that since 1940 new or "modern" fields have been discovered which would have an ultimate recovery, by virtue of present-day operations, of some 23,000 million barrels of crude oil. If it is assumed that two-thirds of them, on a reserves basis, are already producing so as to achieve maximum recovery, and that the recovery in the remainder will ultimately be increased by 50 per cent by application of fluid injection or more effective reservoir depletion control, there is a gain of about 4000 million barrels. In addition, the "older" fields discovered prior to 1941 had, as estimated at the end of 1940, a total ultimate recovery expectancy of some 43,000 million barrels. Assuming that before final abandonment secondary recovery operations will be applied to one-third of these, again on a reserves basis, and that the previously estimated reserves will be increased thereby also by 50 per cent, 7000 million barrels will be the gain.

It is not claimed that the rounded sum of 10,000 million barrels has any more validity than any other guess. But it is submitted that it satisfies the author's intuitive prejudice as being of the right order of magnitude as to what can be done. In any case, it appears that there are potentialities for increasing the presently anticipated reserves by amounts which would well warrant serious effort to achieve even on the scale of the present-day astronomical levels of values.

New Developments on the Horizon

On turning now to the possibility of increasing the present reserves by application of new engineering developments resort must be made to even more speculative considerations. And here it must be recognized that neither the engineering nor economic potentialities can be evaluated at the present time. Nevertheless, it is of interest to review briefly several new types of processes for increasing oil recovery which have at least been actively studied in the laboratory and which may indicate some of the trends of recent research.

It is, of course, no profound observation that an increase in the reserves or oil recovery estimated for a reservoir is possible only by decreasing the

average residual oil saturations left when the field is abandoned. Thinking then in terms of this residual oil saturation, it is recalled that, generally speaking, the solution gas drive mechanism will leave some 30 to 60 per cent residual oil saturation, effective water drives will result in 20 to 40 per cent residual saturations, and that when gravity drainage controls the performance and recovery the residual oil saturation may be 15 to 40 per cent. We have long believed that if a field has been operated by a complete water drive or gravity drainage drive the residual oil saturations of the above orders of magnitude represent oil which is basically irrecoverable, short of mining. The impact on this concept of three recently reported types of research investigation will now be considered briefly.

The first of these relates to the effect of a free gas phase on oil recovery by water displacement. In recognition of the fact that the pressure maintenance capacity of an expansible liquid aquifer is rate sensitive, it has become the practice to limit the withdrawal rates to retard the pressure decline and possibly stabilize them at relatively high pressures. Especially in reservoirs containing undersaturated crudes, the producing rates have been restricted to hold the pressures above the saturation or bubble point. When the natural water-intrusion rates from the aquifer have not sufficed to sustain the pressure above the bubble point at the desired oil-withdrawal rates, the produced waters or even extraneous waters have been injected at the boundaries of the producing formation. Notable examples of such operations are the East Texas and the Midway fields. While admittedly high reservoir pressures are of advantage with respect to operating efficiency and economy, the maintenance of complete water-drive action and *prevention* of free gas phase development has become a critical criterion for presumably insuring maximum recovery. While no authorship is claimed for this proposition, the writer has not infrequently expressed his faith in its soundness. Yet recent research has shown that, at least with respect to the physical processes of oil displacement by water, the efficiency may well be materially increased if a free gas phase has been developed in the porous rock prior to water invasion. Typical laboratory evidence * is illustrated by Fig. 2. Here is plotted the variation of the residual oil left in a sandstone core, after water flooding, with the amount of free gas present initially. It will be observed that for this particular core and experimental conditions a 20 per cent residual oil saturation would result by developing 26 per cent free gas saturation in the sand before water entry, as compared to 34 per cent if the core were water flooded when it contained no free gas—a situation analogous to a natural water drive above the bubble point.

Assuming for the moment the validity of these effects in an actual field, what does this imply? Suppose the field had an initial content of 75 million barrels of undersaturated crude representing 75 per cent of the reservoir pore space. Then, presumably, if it were produced by a complete water drive above the saturation pressure the recovery or reserves would be 41 million barrels. If, however, by pressure lowering and partial depletion, or otherwise, 26 per cent free gas saturation were developed in the pore

* Fig. 2 is a replot of data given by C. R. Holmgren and R. A. Morse (*J. Petrol. Techn.*, 1951, **3**, 135–140).

space ahead of the invading water, only 20 million barrels of oil would be left unrecovered, neglecting shrinkage and related effects. The recoverable reserves would then be 55 million barrels—an increase of 34 per cent over the "perfect" water drive.

It must not be forgotten that the evaluation refers only to laboratory experiments on particular rock specimens. And even if similar results should apply physically to the actual reservoir formations of interest, many other practical problems are involved. Is it feasible to develop the required free gas saturation under actual operations? Will the gas be recompressed and also go back in solution as the water invades the sand? Can the reduced productive capacities resulting from the presence of the free gas phase be tolerated? And will the residual gas and oil saturations seriously lower the water mobility? In a word, is the theoretical gain in recovery

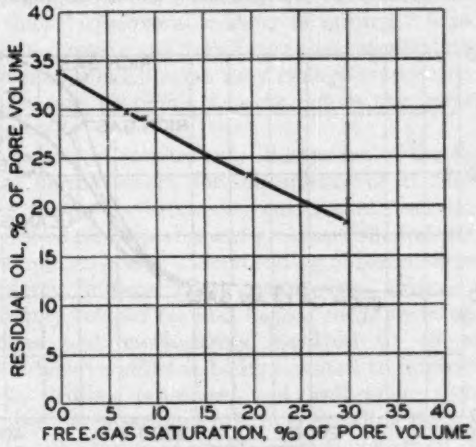


FIG. 2

EFFECT OF INITIAL FREE GAS SATURATION ON RESIDUAL OIL

practical and economically attractive? That certainly cannot be answered affirmatively at present. But it can be said that here at least is a clue to a new approach to water-drive operations which may well lead to increased recoveries and reserves for some of our presently producing fields.

Another type of investigation directed towards significant reductions in the residual oil saturation pertains to gas-drive operations. In the past, primary gas injection has been conducted only to the extent of maintaining the original pressure or retarding the pressure decline. Except when gravity drainage is a major component of the displacement mechanism, the increased oil recovery has been due largely to the additional sweep action of the gas, as determined by the relative permeability relations and the associated effects of reduced reservoir oil shrinkage and viscosity. A recent laboratory study * has shown, however, that if the gas be injected at considerably higher pressures than the reservoir pressure, and if in addition

* Whorton, L. P., and Kieschnick, W. L., Jr., *Oil Gas J.*, 6.4.50, **48**, 78–89. Fig. 3 is taken from this reference.

the injected gas be relatively "rich" in the intermediate components—ethane through butanes—the recovery will be substantially greater than by the hitherto established practices. Illustrative data indicative of such results are plotted in Fig. 3.

There are two phenomena involved. One is the greater tendency to vaporize the lighter ends of the crude both because of the higher pressures and the increased solubility of these components in the gas phase when containing the intermediate hydrocarbons. The other pertains to the application of the process to oils which are originally undersaturated. In such cases, the gas enriched by vaporization during its initial contact with the oil develops an accentuated solubility in the undersaturated crude, and on further contact with the latter leads to a higher total solution gas content and expansion of the resultant reservoir oil. The differences between the two solid or two broken curves of Fig. 3 show the direct effect of gas richness

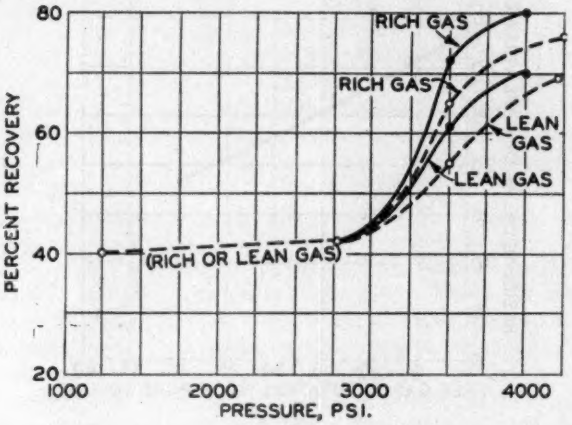


FIG. 3

on the recovery, and the differences between the solid and broken curves give the effect of the crude undersaturation, the former referring to a crude saturated at 2780 p.s.i. and the latter to crudes saturated at the gas-injection pressure. It will be seen that whereas the gas-drive displacement of the 2780 p.s.i. bubble-point crude with a lean gas at or below this bubble point, as would correspond to conventional practice, led to recoveries of about 42 per cent of the initial oil content, applying a rich gas to this same oil at 4000 p.s.i. resulted in an 80 per cent recovery—an increase in the potential reserves of 90 per cent. Under extreme conditions, where the crude oil might be transformed into a saturated vapour by complete retrograde vaporization, a microscopic displacement efficiency of 100 per cent could be theoretically achieved.

Here again it should be emphasized that we are not yet ready to consider this development as an established practicable procedure. While preliminary field tests of this method have been reported as successful, and a large-scale field experiment is being tried in Texas, its applicability may well be

economically profitable only under rather limited conditions pertaining to crude composition, reservoir uniformity, depth, gas availability, etc. On the other hand, this investigation has stimulated new ideas regarding fluid displacement processes and, at least under favourable circumstances, may develop into means for very material increases in the reserves of specific fields.

Another way of reducing the residual oil saturation which has been studied in some detail, and one which can literally reduce it to zero, is the use of miscible solvents. A particular class of interest is LP gas, either as the individual components, propane and butanes, or as mixtures of them. These can, in effect, wash a sand clean of all its oil content, such complete recovery requiring, for example, *iso*butane throughflows of three to five times the oil recovery, depending on the oil viscosity. While such solvent fluids provide, in principle, a means for nullifying the heretofore accepted limit of recovery to that "irrecoverable short of mining," here, too, economic factors raise serious questions as to their practical applicability. But, again, it is conceivable that this situation may change materially with respect to both its technical and economic aspects before the currently producing fields are all depleted.

These examples are, of course, only illustrative of the types of research being carried on in the search for improvements in the methods of oil recovery and for means for increasing current oil reserves. Moreover, in addition to studies on oil-displacement processes the industry is continually working on developing a better understanding of reservoir rocks themselves, their pore geometry, mineralogical constitution, surface properties, etc. These are intimately related to, and indeed form an integral part of, the physical processes and mechanisms involved in oil expulsion. And parallel thereto intensive effort is being devoted to improvements in completion methods, drilling practices, and well-repair techniques. These evidently will play an important role in controlling the overall economics of oil recovery and the limits of profitability to which oil-producing operations can be carried.

What will be the final result of all these research activities? Only a charlatan would pretend to be able to forecast even semi-quantitatively the long-range fruits of such scientific and engineering endeavours. If there is anything which industrial research experience has demonstrated it is that the "unplanned" discoveries are generally far more valuable than those which merely confirm preconceived hopes and prejudices. To have any semblance of effectiveness, organized research must be guided by broad objectives and working hypotheses. But the important progress is represented by the unexpected expansions in the conceptual horizons and by the emergence of new ideas, rather than the scheduled massive accumulation of data to refine the accuracy of previously established correlations.

Accordingly, one must rest content on the faith, based on many years of scientific progress, that the intensive research effort in both the laboratory and field being devoted to the broad problem of improved oil-recovery operations will lead to substantial rewards and in time for significant application to our present producing fields. To assume that such would be equivalent to several thousand million barrels of additional recovery seems to be a conservative estimate, pure conjecture though it be. In any

case, on visualizing such additions, as yet unborn, superimposed on those which may reasonably be expected from extended applications of improved methods of recovery already developed, it appears that an overall increase in our present unproduced crude oil reserves of 50 per cent over that now estimated should be within the range of practicable achievement. And if the general level of economic profitability should improve materially because of increased oil prices or reduced development and operating costs, or if current and future research should mature in the near future into directly applicable new techniques and procedures of oil recovery, the increase may well exceed 50 per cent.

The end of this speculative visit into the future has been reached, and in closing the following observations should be added: The making of an estimate of the probable increase in currently calculated reserves is not of great significance *per se*. The reserves really are what they will be. As the future unfolds, the wrong guesses of the past will automatically correct themselves. If it was known exactly what the ultimate recoveries from the presently known fields actually would be, little more would probably be done than to file the information.

What is important, in the author's opinion, is the awareness of the fact that we can and should successfully strive to increase the efficiency of our oil-recovery operations. However optimistic one may be as to the future of new oil-discovery effort, the only sure and literally liquid assets with respect to oil reside in fields which have already been established as productive. Oil is where it *has been* found. To dissipate these known resources on the premise that future discoveries will indefinitely supply our needs is a luxury and extravagance which can be ill afforded.

While this discourse on the original question has been unsatisfactory in developing a precise answer, it is hoped that it will at least have provided the setting and background for the more challenging and more important question —Our Unproduced Reserves; How Large Can and Will We Make Them?

Discussion

The President: I should like to express to Dr Muskat on behalf of everyone here, our great appreciation of the address which he has just given us. In my opening remarks I did not want to take up too much of your time because we were all anxious to hear Dr Muskat; perhaps now I might just say a word or two concerning him for the benefit of those who are not familiar with the work he has done. Dr Muskat is now Technical Assistant to the Vice President of Production, of the Gulf Oil Corporation. Prior to his appointment to this position, about a year ago, he was Director of the Physics Division of the Gulf Research and Development Company with his headquarters and laboratory at Pittsburgh. He developed there elaborate scientific equipment into which the data from the oilfields can be introduced on the laboratory scale and from which most valuable information can be obtained and applied to the large-scale problems. I regret very much that his time did not permit him to enlarge on that extremely valuable development for which he is responsible. I should like to take this opportunity of expressing my thanks and those of many members of the Institute of Petroleum for the opportunity Dr Muskat and his colleagues of the Gulf

Research and Development Company have given to us when we have been in America in permitting us to see the Gulf Research Laboratory and to be shown all the work going on there.

DR G. M. LEES: We have all listened to Dr Muskat's address with very great pleasure, and I am sure that many of us who have not known him before will have benefited greatly by being able to look at him and to see what he is like. His book, on the physical principles of oil production, plays an important part in the daily lives of most oil engineers nowadays; and it adds greatly to one's appreciation of the value of a book if one can visualize the author.

As a geologist, of course, I take a singularly poor view of the fact that so much effort and talent should be applied to squeezing the last dregs out of existing fields! The endeavour should be rather to find others. But I appreciate that petroleum engineers have their problems, and that squeezing will unquestionably produce dividends. When we see the magical figures of the oil reserves of the United States which are dealt out year after year by the American Petroleum Institute, it is a source of amazement to us all that the reserves of such a great country can be calculated to the nearest thousand barrels. Whilst those figures are accepted by journalists and translated into years of supply, we in the industry know that they are just guesses made on the basis of present producing practice. Dr Muskat has served the cause very greatly by demonstrating that they are not simply magical, but that they depend on the efficacy of production methods. He has shown, for example, that some of the old ideas about water flooding may require revision.

The problem of producing the last dregs from fields, of course, is a combination of physical and engineering principles and of economics. There is a tremendous amount of oil buried in old fields; and even when Dr Muskat has finished with them, there will still be an enormous volume of oil left behind.

He has not touched on some other rather simpler aspects of producing the last squeeze out of the fields, namely, by oil-sand mining or by drainage from galleries. Perhaps he can say what additional reserves can possibly be produced by those methods. Some of us have seen the oilfield at Wietze, in Germany, where the oil-sand is brought to the surface and the last dregs are "cooked" out. That is possible in Germany because of the protected oil price, far above the world average. It would not be profitable in the United States at present, but it may become so in the future, particularly in shallower fields.

One operator had the great idea of putting down shafts and drilling bores from them horizontally. I have visited an oilfield in Australia at Lakes Entrance, east of Melbourne, where a shaft was put down to about 1200 ft. It did not start as a good oilfield, but it demonstrates in a small way what can be done.

WING-COMMANDER E. W. POPPY: From the military point of view, apart from the industrial point of view, may I ask whether the search for reserves might be considered on a global basis? Does the research suggest that exhaustion might occur, particularly having regard to the present

demands of industry in the United States, where such large quantities are being consumed?

DR MUSKAT: As to the possibility of ultimate exhaustion of our reserves, I am somewhat more pessimistic about the situation than I may have a right to be. I am sure Dr Lees would have much more pertinent views about the likelihood of our total ultimate reserves having such a range that we might forecast exhaustion within any particular time. But it is, unfortunately, axiomatic that every field we find leaves one less to be discovered. It is generally agreed that the processes of oil generation are definitely slower than the liquidation by production. As we only have a total, though unknown, amount of oil available for production, sooner or later the time will come when the United States will not have producible reserves sufficient to meet its demands. Whether that situation arises twenty-five or thirty or more years from now I would not guess. But it is a matter which, from both the global and the national standpoints, should be considered very seriously. The effort to discover further reserves is, of course, still being prosecuted vigorously; and we have succeeded in overcoming fears of imminent exhaustion. But we must recognize that ultimately we will come to a maximum production capacity and then a decline will begin. So long as there are tremendous volumes of oil still to be recovered, and we know they are there, it behoves us to do all we can to recover them efficiently and economically.

I have considerably more optimism concerning the development of more efficient recovery through the use of well bores than oil recovery by mining, although, of course, mining is a method we must still bear in mind. But from the world standpoint, as well as from a national standpoint, particularly in a country such as the United States, I would, of course, encourage the continued search for new fields simultaneously with the study of new recovery techniques.

I understand that recent investigations into the production of oil from the Athabaska tar sands are considered to be quite promising. There have been reports recently in the United States that oil from those tar sands can currently be recovered at about 3 dollars per barrel. If that is so, tar-sand production may soon approach the stage at which it will be competitive with normal oilfield producing methods. If these reported procedures for handling tar sands should be confirmed as economically practicable, we shall undoubtedly have to make an abrupt jump in respect of the reserves figures in North America, because estimates show that there are hundreds of billions of barrels which can be recovered from these tar sands.

T. DEWHURST: In regard to the petroleum resources of the world, I have seen unpublished estimates which indicate that proved reserves will last for about fifty years, probable reserves for another fifty years, and possible reserves for another 100 years. It has also been estimated that petroleum reserves from oil shales, coals, and lignites will last for several thousands of years. Estimates other than those of proved reserves are necessarily very speculative.

However, my main purpose in speaking is not to discuss petroleum reserves, but to express personal thanks to Dr Muskat for his very in-

teresting and important paper. Although the discovery of new oilfields is of the greatest importance, it is none the less essential to make the utmost use of our proved reserves, and to effect this the fundamental condition would seem to be the unit development of oilfields. Dr Muskat stated that regulatory bodies in the United States have the power to enforce conservation measures, and therefore I would ask if there has been any agitation in the United States to make the unit development of oilfields enforceable in law.

Although most petroleum geologists are not reservoir engineers, they are much interested in schemes of oilfield development. I therefore offer a suggestion for criticism by Dr Muskat, taking for example the simple case of a dome with an original or induced gas-cap and a well-defined oil–water boundary. In such a case it would seem to be advantageous to estimate the contour at which the gas-cap and the oil–water margin will eventually meet, to confine the drilling of oil-wells to that contour, and to inject gas into the gas-cap and water into the aquifer. Such a development scheme might result in maximum recovery from an oil-pool.

When oilfields approach the economic limit of production, and there must be many such at any given time, then costs of production and prices of petroleum products become of paramount importance and have a crucial bearing on the recoverable volume of proved reserves.

Dr Muskat: The economic limitations are definitely, in my opinion, the crux of the problem of how far along the road of complete recovery we can go. Theoretically, we can recover every barrel of oil in a reservoir by using liquefied petroleum gases as flushing agents. But what would the price of oil have to be in order to pay for it? Our hope is that other methods will become practicable before the price of oil goes up so far as to pay for large-scale solvent drives. In some fields we can even now produce profitably up to 99 per cent water and 1 per cent oil. The amount of estimated recovery must take into account the economic aspects, and when the economic limit for production is changed by the price of oil or by changes in the costs of operation, the total recoverable amount of oil will be affected correspondingly.

As to recovering oil from a field which may have a gas cap and well-defined edge waters, the method suggested by Mr Dewhurst is certainly sound. And it has been tried in a number of instances where circumstances have been favourable. One such case is the West Tepetate field in Louisiana. But, of course, it requires that everybody concerned should get together and allow the production to be controlled and concentrated in the central zone or ring where the gas and water may come together. This type of operation is also currently being studied for the Scurry County fields in West Texas, and plans are being developed for injecting both gas and water. I think Mr Dewhurst's analysis of the situation is perfectly correct. But the operations have to be carried out under unitization.

You inquire whether anything has been done by the United States to enforce unitization. The answer is yes. Such action was started in 1945 by Oklahoma, which enacted a compulsory unitization law. The matter has since been considered by the Supreme Court of the State of Oklahoma, and early this year, by a five to four vote, the Supreme Court of the state

confirmed the validity of the law. However, the state cannot on its own say that a particular field must be unitized; but if a certain fraction of the royalty owners and the operators, namely, 63 per cent according to the present Oklahoma law, agree to the unitization, then the state can force the remainder to join in. Other states now also have compulsory unitization laws, with somewhat different provisions.

Unitized operations are generally conducted by a " unit operator," who produces the oil and gas, and distributes the products. There must, therefore, be agreement in advance as to how the products will be distributed. It is necessary to try to reconcile the ideas of each of those concerned as to how much equity or share each should have in the composite production. In many cases where the stakes are high enough, compromises are reached very quickly. The difficulty comes frequently where there are individual operators who have interests only in the particular field in question. If they do not get what they consider is their fair share in that field, they cannot compensate for their loss by more favourable participation elsewhere. In most cases it is fairly clear on engineering grounds that unitization would be beneficial in the particular reservoir under consideration. But there is the tendency for the operators to ask " why join in a unit simply to increase the profits of the others? " Such difficulties still have not been fully resolved, and it is necessary to encourage and convince all the operators to throw their lot into the common pool and to have faith that, as the result of the operations, everybody involved will gain more than under competitive production.

Those operating in countries outside the United States and Canada are often free of these unitization problems. Many of the fields are owned by single operators or two or three at the most. They do not have to deal with hundreds of royalty owners, who may not fully understand oil-producing operations. Fluid injection can then be undertaken as soon as the engineering analysis shows it to be desirable. In the United States, however, this is only the beginning of the problem, although substantial progress has been made in recent years in expediting the mechanics of unitization.

H. G. KUGLER: Many of the secondary recovery methods mentioned are applicable to the oilfields of Trinidad. We are going to carry out some water-flood experiments on flanks dipping 45° and more. A few years hence we hope to be able to report success.

H. C. LACK: No doubt Dr Muskat has observed in the United States a phenomenon similar to that observed in the United Kingdom, that people can be divided into two classes—those who are always thinking of the good of their fellows, and those who exploit them! This distinction possibly carries over into the oil world. Petroleum engineers are always thinking of the good of their reservoirs, and they are apt to be resentful of those who come to exploit them—especially if that exploitation is at a high rate which might conceivably damage the reservoir.

This point has been touched on by Dr Muskat when he used the phrase " maximum safe withdrawal," which is perhaps much the same as " maximum efficient rate of withdrawal." It might be helpful if he would say what he understands by " maximum efficient rate of withdrawal " or

" maximum safe withdrawal," and what would be the conditions determining it.

DR MUSKAT: If one read all the volumes of legal proceedings relating to maximum efficient rates it would indeed take a long time. We cannot review it all here. While the term " maximum efficient rate " has been abused, it does have significance. It was developed and introduced during the last war; but difficulties arose in its interpretation. As a result, for example, the petroleum authorities in Alberta have decided to use the term " maximum permissible rate," as a more realistic substitute for " maximum efficient rate."

The use of the term " maximum efficient rate " reflects the objective and the desire on the part of both industry and the regulatory authorities to try to produce oilfields at rates which will not lead to avoidable waste of the recoverable reserves. Since such waste may be sensitive to the rate of withdrawal for a field as a whole, the company engineers and the regulatory authorities meet at hearings to agree on rates of withdrawal which they feel will be safe and will insure the avoidance of waste. However, these are not permanently fixed values. They are subject to re-hearing or re-examination and debate as to what the future rates should be in the light of new information. The point is that, if uncontrolled production will lead to waste, some limitations on the producing rates must be imposed. The " maximum efficient rate " thus represents a ceiling below which it is felt that the oil recovery will be obtained efficiently in the light of the characteristics of the reservoir in question.

E. C. MASTERSON: The three new thoughts put forward by Dr Muskat regarding possible ways of increasing production are certainly most interesting. The last two appear to me, at any rate at the moment, to be uneconomic. One cannot envisage at the present time how the price of crude would ever permit the injection of solvents on an economical basis; conditions may change, of course, in years to come. The first idea seems absolutely revolutionary to those of us who have been in the industry a long time; it is an idea absolutely contrary to present-day production practice, and I for one would be most interested to know of any developments. If I understand the position correctly, Dr Muskat has based his views on a single laboratory test, or a few such tests, but certainly not on tests in the field.

I should like to ask a question about the reserves figures; during the discussion, Dr Lees has referred to such figures being given with a very great degree of accuracy, in fact, to the nearest barrel. The graph in Fig. 1 indicates the growth of the proved reserves and production rates from 1930 to date, and shows that the proved reserves in 1951 are 25 thousand million barrels. During the period from 1930 to 1951 a number of fields must have been depleted, *i.e.*, fields included in the 1930 proved reserves figures but no longer included in 1951. I have never seen any comparison between actual production from fields and the figures previously given in reserves estimates.

I wonder whether Dr Muskat can throw any light on this, and whether he has seen any comparisons between estimated reserves and actual yields

from any depleted fields. Such information would give an indication of the reliability of reserves estimates.

DR MUSKAT: I am inclined very much to agree with you that some of the methods we have discussed for increasing oil recovery may seem to be rather impracticable. Certainly the use of solvents is uneconomic at the moment. High-pressure gas injection is being tried by the Atlantic Refining Company in West Texas. We do not know yet whether it will work successfully in the sense of actually increasing the recovery enough to pay for the increased cost of the operations. Laboratory studies indicate that it ought to be successful, and the field tests should be a final check.

I agree also that the suggestion to permit free gas-phase development before water drive is revolutionary. It seems to have been first proposed by the Standard Oil Company of California. Their laboratory work has been confirmed by Stanolind Oil and Gas Company, and the Gulf Research and Development Company has also obtained similar results. As to whether or not the method will work in actual field practice, it is difficult to say. There are many practical difficulties involved. It is possible, however, that many of the water floods which have been undertaken for secondary recovery may owe their success, at least in part, to the fact that they were started after primary depletion and a free gas phase had developed in the sand.

As to a direct field check on reserves estimates, there is always a simple answer which reservoir engineers could give for all cases, namely, that one can never prove them wrong! As regards predictions made in the early 1930s the records are unfortunately too meagre to enable one to check anything of significance. And even for fields developed in recent years comparisons of ultimate recovery predictions, or reserves, with actual experience are not easy to evaluate. Part of the difficulty is that, as more information is developed in any field, the predictions are changed. Hence, as time goes on the predictions automatically become better. In general, however, one should be able to estimate the reserves rather accurately after a field has had some 25 per cent recovery history.

H. S. GIBSON: In connexion with most of the matters Dr Muskat has raised I find myself in complete agreement with him. First, no two fields are alike, and the only way in which to discover what fields can do is to produce. I think all practical men will agree that it is impossible to make forecasts at the moment a field is discovered; we have to develop the field and produce from it before we can begin to understand it and say what can be done with it.

On the question of increasing recovery, I appreciate, of course, that Dr Muskat has not had time to go into details; he has covered the subject broadly. The volume, of course, depends very largely on the type of reservoir, and the size and shape of the pores. The geometry of the pore-space is extremely important; if one dimension is appreciably less than the others, conditions are completely changed. Then the question of adsorption comes in; the heavier molecules are held by the surface of the pores, and the oil produced from the flowing wells is often quite different from that which is *in situ* in the field. That has often been shown by extractions from pores.

This increased recovery, of course, will have to take into account the fact that, as more and more oil is produced, we may get a very different material from that which the field produced initially.

A matter on which I should like Dr Muskat's views is that of time. That is a factor which is of extreme interest to production engineers, but unfortunately it is the one factor over which they have very little control. The fact that the investment in the field has to be covered within a reasonable space of time very often forces the production engineer along at a pace at which he would otherwise be unwilling to go.

DR MUSKAT: I think the time element is related primarily to the question of the maximum efficient rate of withdrawal; *i.e.*, a balance between the rate of recovery and efficiency. As Mr Gibson has indicated, we must combine engineering and economics to determine the optimum producing method and rate. One may have to sacrifice an absolute maximum recovery to achieve an economic recovery. One cannot follow an extreme and limit the production rate to infinitesimal values just because one might thus obtain a slightly higher maximum physical recovery. One must produce at rates which will be profitable and give a reasonable life to the operations as a business venture. In some fields, fortunately, the producing rate will not have an appreciable effect on the recovery. But in most cases we must combine economic realism with the engineering concepts to get a resultant optimum rate which will be both profitable and efficient.

WING-COMMANDER E. W. POPPY: The title of the paper is "Our Unproduced Reserves," and I know it concerns principally the United States of America. May I ask whether the reserves in the United States balance those in the limestone of the Texas fields?

DR MUSKAT: I really do not know. The Texas Railroad Commission, which controls the production in the State of Texas, recently indicated there was available a slack or a cushion of about a quarter of a million barrels per day in that state for further expansion if necessary. That may also apply in other states, though I have no further data on the subject.

VOTE OF THANKS

THE PRESIDENT: In concluding our meeting I want to express again our great appreciation. Dr Muskat must be feeling tired, as he has given us two hours and has replied to every question in a most stimulating way. I do not think we have ever had an address with questions where the lecturer has been so patient in answering fully every question which he has been asked. I should like in conclusion just to read a few lines from the introduction to Dr Muskat's book. They, I think, put in a nut-shell, the problems which have been under discussion this evening:—

> "The physics of oil production is unique among all applications of physics. It deals with objects—the oil reservoirs—that are variable continua, subject only to virtually infinitesimal sampling. Their physical histories are irreversible transients that can be observed

only at isolated points 'on the fly.' They are controlled by a trinity of forces—hydrodynamic stress gradient, gravity, and interfacial—superposed on a trinity of phases—oil, gas, and water. Except for relatively microscopic laboratory investigations, any major and significant field experimentation creates an irreversible change in the state of the system and destroys the possibility of repeat or comparative experimentation on the same reservoir. And finally there are no identical specimens in the ensemble of the objects of study. Yet the goal toward which the study of this subject strives is the prediction and interpretation of the detailed behaviour of *individual* reservoirs! Little wonder is it that the subject is hardly beyond the state of infancy."

(The vote of thanks was accorded with enthusiasm.)

INFLUENCE OF CARBON DISULPHIDE ON OCTANE NUMBER AND LEAD SUSCEPTIBILITY

By Geo. E. Mapstone * (Fellow), and J. S. Durham *

Summary

The effect of carbon disulphide on the octane number and lead susceptibility of 60 O.N. reference fuel has been determined.

There appears to be no reliable data on the presence of carbon disulphide in crude oil or straight-run gasolines,[1] although it may be formed during cracking if free sulphur is present,[2, 3] and thus possibly be present in trace amounts in some cracked gasolines. It is, however, a normal constituent of coal-tar benzole, which is frequently blended with gasoline, and has been identified in shale naphtha.[4] Subsequent work has shown it to be present in concentrations as high as 0·27 per cent sulphur in the gasoline produced from the thermal cracking of shale oil.

Livingston [5] has collected the data published by various investigators on sulphur antagonism and calculated the loss in lead efficiency for fuels containing various sulphur compounds. The data of Birch and Stansfield [6] on the effect of carbon disulphide on lead susceptibility is meagre, and not included by Livingston in his paper. The present investigation was undertaken to remedy this deficiency.

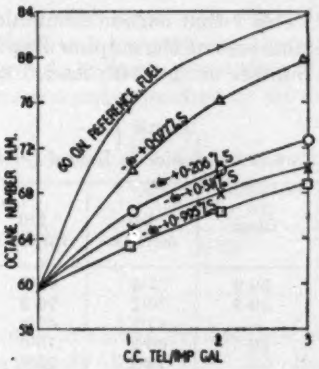


Fig. 1

OCTANE RATING OF LEADED BLENDS OF CARBON DISULPHIDE

Experimental

The reference fuel chosen as the base fuel was a 60/40 blend of *iso*-octane/*n*-heptane, and to this was added varying quantities of freshly distilled carbon disulphide. The octane numbers of these samples were determined by the Motor Method, clear and leaded.

The octane numbers of samples with varying concentrations of sulphur as carbon disulphide are shown in Table I, and graphically in Fig. 1 with

* National Oil Proprietary Ltd., Glen Davis, N.S.W., Australia.

a blending curve for the base fuel. From these results the loss in lead efficiency as defined by Livingston [5] was calculated for each concentration of sulphur. This is shown graphically in Fig. 3, the calculated results appearing in Table I.

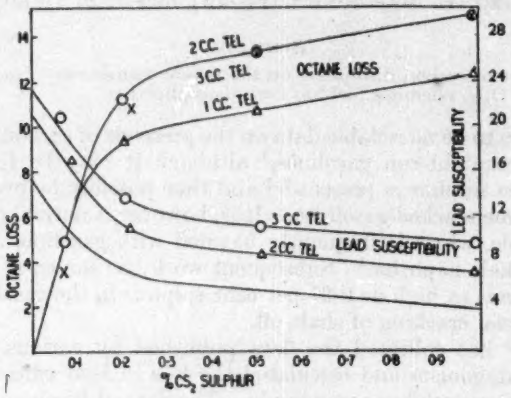


FIG. 2

OCTANE LOSS AND LEAD SUSCEPTIBILITY

DISCUSSION OF RESULTS

It is apparent from Table I that carbon disulphide has very little effect in reducing the octane numbers of the sulphur-free base fuel. However, a marked loss in octane number occurs with leaded samples.

TABLE I

Effect of Carbon Disulphide in Leaded Reference Fuel

Carbon disulphide, % S by wt		Clear	1·0 ml/I.G.	2·0 ml/I.G.	3·0 ml/I.G.	Mean TEL loss
Nil	O.N.[a]	59·9	75·4	81·2	83·6	—
0·077%	O.N.	59·3	70·2	76·2	79·6	—
	L[b]	—	47%	46%	47%	47%
0·200%	O.N.	59·7	66·2	70·0	72·8	—
	L	—	74%	75%	76%	75%
0·511%	O.N.	59·5	69·4	68·0	70·4	—
	L	—	80%	82%	82%	82%
0·995%	O.N.	59·5	63·2	66·4	68·8	—
	L	—	87½%	86½%	86	87%

[a] O.N. by Motor Method.

[b] L = loss in lead efficiency $= a_0 - a/a_0 \times 100$, where a_0 = actual TEL concentration and a = TEL concentration in the sulphur free fuel corresponding to the observed O.N.

Octane loss, *i.e.*, the difference between the octane number of the sulphur-free leaded base fuel and that of the sulphur-containing sample, was very similar for 2 and 3 ml TEL concentrations.

As shown by Livingston [5] the loss in lead efficiency is substantially the same at the same sulphur concentration and is independent of the amount of TEL added. For example, at the lowest carbon disulphide sulphur concentration (0·077 per cent S) the loss in lead efficiency was 47, 46, and 47 per cent for 1, 2, and 3 ml TEL respectively. The greatest relative loss in lead efficiency is observed with the lowest concentration of sulphur as can be seen from Table I.

Thus, even 0·05 per cent of carbon disulphide sulphur can give a loss in lead efficiency of the order of 30 per cent. This was illustrated by dividing

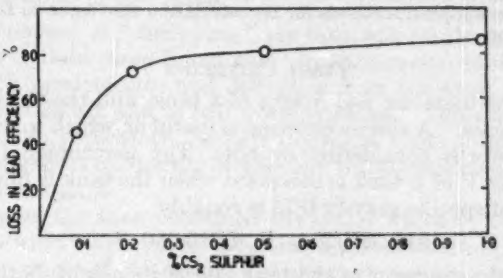


FIG. 3

LOSS IN TEL EFFICIENCY

a sample of leaded (1·7 ml TEL per gallon) shale gasoline into two equal parts, which were washed with equal volumes of aqueous and alcoholic sodium hydroxide to duplicate evaporation losses. The alcoholic alkali wash, as expected, removed the large proportion of the carbon disulphide and gave the higher octane number product as shown in Table II.

TABLE II

Caustic wash	Carbon disulphide, % S by wt	O.N. (M.M.)
Aqueous	0·03	69·3
Alcoholic	0·01	70·2

From Fig. 3 this decrease in carbon disulphide should give an increase in lead efficiency of approximately 12 per cent. The initial lead susceptibility was seven numbers an increase of one-seventh of this, *i.e.*, approximately one number, could be expected. This compares very favourably with the O.9. O.N. increase observed.

References

[1] Sachanen, A. N. "The Chemical Constituents of Petroleum," p. 367. Reinhold Publ. Corp., New York, 1946.
[2] Wheeler and Francis. B.P. 351,994, 1930. *Brit. Chem. Abs.* B, 1931, 960.
[3] Ellis, C. "Chemistry of Petroleum Derivatives," Vol. I, p. 185. Chem. Catalogue Co., New York, 1934.
[4] Mapstone, G. E. "Some properties of crude shale oil and naphtha." Oil Shale & Cannel Coal, Vol. 2. In the press.
[5] Livingston, H. K. *Industr. Engng Chem.*, 1949, **41**, 888–93.
[6] Birch, S. F., and Stansfield, R. *Industr. Engng Chem.*, 1936, **28**, 668.

THE EXPANSION OF VERTICAL CYLINDERS UNDER LIQUID HEAD

By Peter Kerr (Fellow)

Summary

The sides of a vertical cylinder are pressed outwards when the tank is filled with liquid, and so they expand, this increasing the capacity of the tank. This note discusses the amount and technical effects of this expansion, and gives the simplest methods for its calculation that have so far occurred to the author.

First Criterion

The smaller the diameter and height of a tank, and the thicker its plates, the less it expands. A simple criterion is useful on which to decide whether expansion is worth considering or not. The percentage by which the empty capacity V of a tank is increased when the tank is filled completely with a liquid of specific gravity 0·75 is roughly

$$100 \,.\, dV/V = D \,.\, H/10{,}000 \,.\, t \quad . \quad . \quad . \quad (1)$$

in which D is the diameter of the tank and H its height, both expressed in feet, while t is the thickness, in sixteenths of an inch, of the plates of its middle ring. If the tank has an even number of rings, and so no middle ring, the thickness of its plates just below mid-level may be taken into calculation, when the expansion tends to be a little under-estimated.

As examples, a tank 12 ft in diameter and 18 ft high made of $\frac{3}{16}$-inch plate on being filled completely with gasoline would increase in capacity by about 0·007 per cent of its capacity, or by less than a gallon. This is one of the smallest API standard tanks; at the other end of the scale, the standard API 8-ring 168-ft tank with plates 100 inches high has a $\frac{7}{8}$-inch plate just below mid-level. The tank is about 64·7 ft high, and it has a total capacity of about 255,000 brl; it will expand by about 0·077 per cent of its total capacity on being filled with gasoline, that is, by nearly 200 brl (8000 U.S. or 7000 Imperial gallons).

These are extreme cases; to obtain a fair view, the effect should be calculated both in percentage and in volume. Gallonage expansion would probably be still larger for larger tanks, but it would be incorrect to assume that percentage expansions would then be notably greater than 0·08 per cent. These percentages are in effect a measure of the weakness of the sides of a tank, and this in turn is limited by sound design.

Part Deliveries and Receipts

The addition of a small depth of liquid to a tank nearly full increases the liquid head over all lower rings, so that the greater part of the expansion takes place as the upper levels are filled; conversely, the greater part of the elastic contraction takes place as these levels are emptied.

A rough numerical estimate of the effect may be obtained from formula (1). If the two top rings of the 168-ft API tank are emptied, the remaining six rings have a total height of about 48½ ft, and the ring just below mid-level is 17/16-inch thick, so that the approximate expansion by

formula (1) is now 0·048 per cent. This, however, is reckoned on the capacity of the six rings of the tank; reckoned on the whole tank, the percentage is 0·036. On removal of one-quarter of the total contents of the tank, roughly half of the total expansion of 200 brl has been lost. Reckoned on the amount removed from the tank, the contraction of the tank adds to that quantity by about 0·16 per cent, or about twice the percentage expansion calculated for the whole tank. Smaller quantities delivered from higher gauges will be affected similarly, but by slightly higher percentages.

Effects of Conditions at Strapping

If at measurement or " strapping " the tank was empty or nearly so, the full tank will contain more liquid than an uncorrected table for it would indicate; both receipts into and deliveries from the tank will be under-estimated, and this can add to real working losses. This under-estimation will be highest in percentage for part deliveries made from high gauges; those from low gauges will hardly be affected, but there is no over-estimation at any level in the tank.

If at strapping the tank contained the liquid which it normally stores, and if it is always filled up to the same level as at strapping, then provided that the whole of the contents of the tank are dealt with in a single calculation, the result should be accurate. This may be closely the case with a gathering tank, if individual receipts into it are either totalled or not calculated; or with tanks delivering the whole of their contents at one time, as is often the case in pumping into pipelines or in loading tankers. The uncorrected table will lead to under-estimation of part deliveries from high gauges, but since the table is correct as a whole, there will be compensating over-estimation of deliveries from low gauges.

Final Criteria

In deciding whether or not to correct a tank table for expansion effects, consideration may be given not only to the overall percentage and volume figures obtainable from formula (1), but also to the way in which the tank is to be used, and the percentage accuracies it is desired to reach in the measurement of relatively small quantities received into or delivered from any of its levels. Complete neglect of tank expansion in calculating amounts of oil transferred is not likely to lead to percentage errors in the calculated amounts exceeding say 2½ times the percentage calculated from formula (1), and this maximum will be reached in a small proportion of cases only; quantities transferred from run-down tanks to top up main storage tanks seem likeliest to be affected. Non-technical factors also enter, but these are not discussed here. When it is desired to allow for tank expansion, the approximate methods given below adequately correct the tables.

Strapping Conditions and Process of Calculation

A practical advantage of correcting for expansion is that tanks may be strapped when filled to any depth with any liquid; the tank is not long out of use. As a first step in calculation, the measured circumferences are corrected by taking out of them the effects of any liquid in the tank, the results being the " empty " circumferences, those which would have been

obtained if the tank had been strapped empty. As a second step, the calculated effects of the liquid to be stored are then brought back into the empty strappings, in such a way that the " final " or fully corrected circumferences may be calculated direct to areas and volumes in the usual way, and yet produce a table reasonably well corrected for all expansion effects.

This is the straightforward method, and for clarity it has been set out below. Since the constants used are closely related, in practice the two steps may be combined in various ways; but these are left to the user's choice.

Basic principles are the same in both steps, but their application differs. At strapping, the specific gravity and the depth of the liquid in the tank, and therefore its pressures, are definitely known, while the specific gravity of the liquid which is later on to be stored in the tank must be estimated. Again, at strapping the liquid surface is at a fixed and definite level, though not in general at the top of a ring. In the second step, the liquid is supposed to rise in the tank, and expansions are calculated in stages, as the liquid reaches the top of each ring, or more precisely, the middle of each horizontal seam. As the tank fills, all the lower rings continue to expand under the added head, and these additional expansions are allowed for. The two steps are therefore distinct, the first always being simpler than the second.

Second-order Effects

Even for the largest tanks, the total effect of expansion is small, so that second-order corrections are generally negligible. Each ring is regarded as a cylinder, and if it is full of liquid, its expansion at mid-level is taken as the true average for the whole ring. The gravity of the liquid is taken as uniform at all levels, and small inequalities in ring heights and circumferences are disregarded. Strictly, it is the mean circumference for all rings which would best be taken into calculation, but it is sufficient to choose from among the strappings a circumference near this average.

The bottom angle-iron, attached as it is to practically inextensible bottom plates, restrains the expansion of the bottom ring at levels near it. In the example, this is sufficiently allowed for by first calculating from formula (2) below the expansion of the bottom ring, and then taking into all further calculations 80 per cent of the figure so calculated.

The effects of stiffening rings made of angle-iron could hardly be neglected, but these are unusual in present designs. Buttstraps also tend to restrain the expansion of their ring. Their effect is sufficiently allowed for if in calculating its expansion, the plate thickness of the ring is increased to the thickness that would be shown if the metal in the buttstraps were spread uniformly over the whole surface of the ring. This correction has not been applied in the example; the whole question of these and other restraints on expansion has been discussed elsewhere.[1]

Calculations

A 10-inch slide-rule is adequate for the arithmetical products and quotients needed, and the rest of the arithmetic is adjusted roughly to this simple standard.

[1] Kerr, Peter. " Restraints on the expansion of vertical tanks under liquid head." *J. Inst. Petrol.*, 1951, **37**, 328.

Correction of Strappings to Empty Circumferences

The formula used is developed in the appendix.

$$dC_n = -A \cdot h_x/t_n \quad . \quad . \quad . \quad . \quad (2)$$

in which A, a constant for any one tank, is given by

$$A = 4{\cdot}56 \cdot 10^{-7} \cdot C^2 \cdot g \quad . \quad . \quad . \quad (3)$$

In these, dC_n is the expansion of the circumference C of the tank under a head of h_x of liquid of specific gravity g at a level where the thickness of the side-plates is t_n. C, dC_n, and h_x are in feet, while t_n is in sixteenths of an inch. The suffix n is the ring-number, reckoned upwards; the application of the formula is best seen from an example.

Suppose that the eight-ring 168-ft API tank already discussed had been strapped when it contained $G = 34{\cdot}28$ ft of water of gravity 1·00. The tank circumference is about 528 ft, so that $A = 0{\cdot}127$. The total height of the tank is about 64·7 ft, so that the height of each ring is $h = 8{\cdot}09$ ft, and $\frac{1}{2}h = 4{\cdot}04$ ft. The calculation then runs :—

					dC_n	
	$G = 34{\cdot}38$	n	t_n	h_x/t_n	Calcd	Corrd
$-\frac{1}{2}h$	4·04					
	$h_x = 30{\cdot}24$	1	23	1·31	−0·166	−0·133
$-h$	8·09					
	$h_x = 22{\cdot}15$	2	20	1·11	−0·141	−0·141
$-h$	8·09					
	$h_x = 14{\cdot}06$	3	17	0·83	−0·105	−0·105
$-h$	8·09					
	$h_x = 5{\cdot}97$	4	14	0·43	−0·055	−0·055
$-\frac{1}{2}h$	4·04					
Remainder	1·93					

If the gauge G has not been taken from tank-bottom level it is first corrected to this. The depth of water over mid-level of the first ring is then obtained by subtracting half the ring height, taken as constant for all rings; this gives h_x as 30·24 ft, and as the plate thickness is 23/16-inch, h_x/t_n for that ring is 1·31 and dC_n 0·166 ft. The expansion calculated at mid-level for each ring is taken as the average expansion for the ring, but for the bottom ring in this case 80 per cent of the expansion first calculated is taken, to allow for the restraining effect of the bottom angle-iron, see explanation above. Repeated subtraction of the ring height gives h_x for the second and higher rings, dC_2, dC_3, and dC_4 being calculated exactly as dC_1, but without further correction.

In preparing tank tables, it is usual to regard each ring as cylindrical, strappings being averaged to obtain a mean apparent circumference. The values of dC_n are the footages which should be subtracted from the mean circumferences as strapped to reduce these to mean "empty" circumferences.

So that the example may be followed easily, all intermediate figures have been shown, but in practice only a few figures other than the first and last columns need be written down.

Rings Partly Filled

If a ring is not full of liquid, then strictly its expansion at mid-level should not be applied as an average correction to the average of all strappings on the ring. If the ring is nearly full, it is often sufficient to treat it as if it were

full; while unless it is nearly full, its expansion under the small head of oil in it may be negligible. If greater precision is desired, using formula (2) expansions may be calculated for the levels which have been strapped under liquid head, and these expansions subtracted from the circumferences measured at those levels. The results are empty circumferences at the strapping levels, and they may be averaged with any other empty circumferences for the same ring. It will be seldom that this process adds more than one calculation to those otherwise needed for the expansion of the tank.

As soon as the main calculation shows an h_x less than h, $\frac{1}{2}h$ is subtracted, if possible; in the example, 4·04 is subtracted from 5·97. Any remainder then shows that the liquid surface lies in the next higher ring, in the example the fifth. If as here the next lower ring is full, calculation and use of its mid-level expansion as an average is justified. In the example, the depth of liquid in the fifth ring is so slight that it would waste time to calculate its effect on the lowest strapping on the fifth ring, if such a strapping were taken; but in other cases there may be one or two separate calculations at levels in the upper ring.

If $\frac{1}{2}h$ cannot be subtracted, the lower ring is not full, and corrections at separate strapping levels may require to be calculated for it. It may therefore be useful to complete the first column of the calculation before going on to the rest of the work.

Omission of this Calculation

This calculation is of course not required if the tank has been strapped empty, or if it contained so slight a depth of liquid that its expansions were negligible. There are at least three possible courses in the latter case.

(*a*) When a consistently designed tank is one-fifth full, its expansion is only about 3 per cent of that calculated from formula (1) for the full tank; this 3 per cent is generally negligible, and it would not be unreasonable to make the rule that if a tank is less than 20 per cent full at strapping, no correction need be calculated.

(*b*) Alternatively, a maximum of so many feet of liquid may be chosen, but this does not provide quite so satisfactorily for all cases.

(*c*) It is good practice to record the depth and gravity of the liquid in the tank at strapping, even if it is thought that strappings will not need correction. If this is done, the first line of the calculation given above may be completed, and if the correction figure so obtained turns out to be negligible, corrections for all higher rings will be less still, and the case for neglect is proved.

Calculation of Final Circumferences

The formula used is

$$dC_n = B/t_n \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

in which B, regarded as a constant for any one tank, is

$$B = 4{\cdot}56 \,.\, 10^{-7} \,.\, C^2 \,.\, g' \,.\, h \quad . \quad . \quad . \quad (5)$$

This is a simple variant of formula (2); as before, dC_n is the expansion of the circumference C of the tank, both in feet, at a level at which the liquid head is h feet and the side-plate thickness t_n sixteenths of an inch. Values of

dC_n are, however, calculated from this formula only for the mid-levels of each ring, and only when the head of liquid over that level is equal to the height h of a ring. Since all rings are assumed to be of equal height for any one tank, h is now constant and equal to H/N, H being the total height in feet of the tank and N the number of its rings.

The specific gravity of the liquid which is to be stored in the tank is g'; the choice of a value for g' is discussed below.

Progressive Expansions

The values of dC at any one level are proportional to the head of liquid over that level. If the bottom ring is just full of liquid, then neglecting for the moment the restrictive effect of the tank bottom plates, the expansion of that ring under its mean liquid head $\frac{1}{2}h$ is obtained by taking one-half of the figure calculated from formula (4), in which the assumed liquid head is h. The figure obtained directly from the formula may be called f_1, when the expansion in question is $\frac{1}{2}f_1$.

If the second ring is just full, the head of liquid over mid-level of the bottom ring is $1\frac{1}{2}h$, and the expansion of the bottom ring is now $(\frac{1}{2}f_1 + f_1)$. If the third ring is just full, the bottom ring expansion is $(\frac{1}{2}f_1 + 2 . f_1)$, and so on, when higher rings are just full. Successive expansions for the bottom ring may therefore be calculated by repeated addition of f_1 to an initial value of $\frac{1}{2}f_1$. Making the calculated allowance for the restraining effect of the bottom plates, f_1 is reduced to 80 per cent of the value calculated from formula (4), and this reduced value is taken into all its multiples and sub-multiples above.

Similar arguments apply to the expansions at mid-level of the second and higher rings; using the appropriate values of t_n, the formula gives f_2, f_3, and so on, for these. Figures for all mid-level expansions as the liquid surface reaches the top of each successive ring are therefore readily obtainable, but only those for the bottom ring need be corrected for restraint.

Re-allocation of Expansions

The additional expansion f_1 of the bottom ring as the liquid surface rises from its top to the top of the second ring does not provide additional capacities which can be tabulated against oil depths lying within bottom-ring levels. This expansion takes place as the second ring fills, and so the additional capacities which it provides should be tabulated as adding to the capacity otherwise available at second-ring levels. As the liquid surface rises from the top of the second to the top of the third ring, the further expansions f_1 and f_2 of the bottom and of the second ring take effect in the volumes which should be tabulated in the third ring; and so on. Since the expansions concerned are small, and the circumferences of all rings substantially equal, the tank table will be sufficiently corrected if the additional circumferential expansions of the bottom ring are credited successively to the circumferences of the second, third, and higher rings, those of the second ring being similarly credited to the third and higher rings; and so on. In other words, when the pth ring of the tank is just full, its actual expansion is $\frac{1}{2}f_p$; but the expansion to be credited to the ring is $f_1 + f_2 + \ldots + f_{p-1} + \frac{1}{2}f_p$. The ease with which this cumulative process can be applied arithmetically is best seen in an example.

For the 168-ft API tank, with $C = 528$ and $h = 8{\cdot}09$ ft, taking g' as 0·75, $B = 0{\cdot}771$ from formula (5). Values of t_n in sixteenths of an inch are shown in the second line of Table I; the third line sets out values of B/t_n, which can be read off from one setting of the slide rule by reversing the slide. The value set down for the first ring is 80 per cent of its calculated value 0·034, see above, this allowing, once for all, for bottom-plate restraint.

TABLE I

Ring	1	2	3	4	5	6	7	8
t_n	23	20	17	14	11·5	8·5	6	4
B/t_n	0·027	0·039	0·045	0·055	0·067	0·091	0·128	0·193
	0·000	0·027	0·066	0·111	0·166	0·233	0·324	0·452
$\frac{1}{2}B/t_n$	0·014	0·020	0·022	0·028	0·034	0·046	0·064	0·096
dC_n	0·014	0·047	0·088	0·139	0·200	0·279	0·388	0·548

The figure 0·027 under ring 2 in the fourth line is obtained by copying down that given in the third line under ring 1. The two items 0·027 and 0·039 now under ring 2 are added together and their sum 0·066 is written into the fourth line under ring 3. The process is repeated along the fourth line, each succeeding entry being the sum of two items lying immediately to its left. The entries in the fifth line are obtained by halving the corresponding entries in the second, while those in the sixth line are the sums of those in the fourth and fifth.

The whole process gives the cumulative effects required, so that the results in the sixth line are the footages which should be added to the mean empty circumferences of the rings indicated, to obtain final circumferences. These last, when calculated to volumes-per-unit-depth in the usual way, will give tabular volumes corrected for the varying effects of liquid head in the tank.

Comparison with Formula (1)

From the results just given, the average expansion per ring is $dC = 0{\cdot}213$ ft, so that $2 \cdot dC/C = 0{\cdot}00081$; but this is dV/V as defined for formula (1), so that $100 \cdot dV/V = 0{\cdot}081$ per cent as compared with 0·077 per cent from formula (1). Formula (1) is broadly reliable when applied to the whole depth of a consistently designed tank, but it is less satisfactory when it is applied to calculate the average expansion of the lower part of such a tank, as has been done in the earlier parts of this note.

THE SPECIFIC GRAVITY OF THE LIQUID TO BE STORED

For a commercially pure liquid, or any other product substantially constant in specific gravity, little difficulty arises in the selection of a suitable value for its estimated future average gravity g'. If the product is relatively costly, so that precision in its measurement is important, as is often the case with products of this type, it may be desirable to make the expansion correction using this value of g'.

Accuracy in the choice of g' is less easily secured in other cases, particularly when the tank may be changed over from one product to another of substantially different gravity. The difficulty could, of course, be met by revising the tank table when the product in it is changed. This will usually be impracticable, when greater uncertainty in g' must be tolerated; much depends on the value of the product, the size of the tank, and the accuracy it is desired to attain in measurement. Two possible courses suggest themselves for petroleum products.

A tank which stores black oils is seldom returned to white-oil storage, and white-oil tanks continue to be used for these oils over many years. The rule might be adopted that for all white oils an average gravity of 0·75 might be assumed, while for all black oils 0·90 might be adopted.

Failing this, 0·80 might be assumed as a fair average for the whole range of petroleum products stored in the common type of tank. Heated bitumen or asphalt can perhaps be disregarded in choosing this average, since other errors in the bulk measurement of this tend to be high. Propane and butane are rightly excluded, since these must be stored in pressure vessels, and the expansion formulæ given do not apply to these.

Acknowledgments

The author is indebted to F. Barnes, B. C. Ferguson, and H. R. Holmes for their check on the formulæ proposed, the arithmetic of the examples, and for valuable comment.

APPENDIX

Derivation of Formulæ

In its general form, the basic formula used for calculating expansion is

$$dR = p \,.\, R^2/E \,.\, t \quad . \quad . \quad . \quad . \quad . \quad (6)$$

in which dR is the change in radius R of a cylinder under the radial pressure p, the plate thickness at the level concerned being t, and E being Young's modulus of elasticity for the material of which the cylinder is made. The formula does not apply to cylinders in which the pressure puts the sides into longitudinal tension.

Units used must be consistent; Young's modulus is usually taken in pounds per square inch, when p must be in the same units, and dR, R, and t in inches. This is the rule usually safest in practice, but there is in fact greater freedom in choice. Writing equation (6) in the dimensionless form $(dR/R) = (p/E) \,.\, (R/t)$, it is clear that while within any one pair of brackets there must be consistency, the units used are otherwise independent. The point simplifies some of the numerical conversions discussed below.

Taking the weight in air of a cubic foot of water at 60° F as 62·30 lb, and $29 \,.\, 10^6$ p.s.i. as a mean value of Young's modulus for structural steel, formula (6) may be written

$$dC = 4{\cdot}56 \,.\, 10^{-7} \,.\, C^2 \,.\, g \,.\, h/t \quad . \quad . \quad . \quad (2)$$

This is formula (2); its units and the meanings of its symbols are given in the text above. Formula (4) follows very simply from formula (2).

Formula (1) assumes that since any tank is or should be consistently designed for strength, the percentage expansion of the middle ring when the tank is full is a fair average for the tank, if a 7 per cent allowance is made for the restraining effect of the bottom angle-iron and for the usually disproportionate strength of the top courses.

Calling the volume, diameter, and height of the tank V, D, and H, and the plate thickness of its middle ring t, taking g' as 0·75 and remembering that when the tank is full, the head of liquid overmid-level in it is $\frac{1}{2}H$, substitution for dC from equation (2) in the equation $dV/V = 2 \,.\, dC/C$ leads to

$$dV/V = 1{\cdot}07 \,.\, 10^{-6} \,.\, D \,.\, H/t \quad . \quad . \quad . \quad (7)$$

Writing unity for 1·07, and so making the 7 per cent allowance mentioned,

$$100 \,.\, dV/V = D \,.\, H/10{,}000 \,.\, t \quad . \quad . \quad . \quad . \quad (1)$$

in the units specified for that equation.

Alternative Formulæ

The formulæ given above apply to measurements in feet and lb, and give corrections directly applicable to circumferences only. The author prefers to allow for tank expansion by correcting circumferences, but there is no difference in results if expansion is allowed for by correcting volumes-per-unit-depth in place of circumferences. The formulæ given below are more convenient when diameters have been measured, when expansions are required in terms of volume, or when working in metric units.

If C, D, and v are the circumference, diameter, and volume-per-unit-depth of the cylindrical ring of a tank, then $2 \cdot dC/C = 2 \cdot dD/D = dv/v$. All these ratios are dimensionless, so that they do not imply the use of any particular unit; examples of some of their applications are given below. dC and dD are normally calculated for mid-level of the ring concerned; and since dv/v is dimensionless, formulæ based on it will give the increase in volume for the whole ring, or per inch, or per foot, according as v is taken as the volume of the ring, or the volume per inch or per foot of this.

Calculation on Diameters

Substituting the value of dC_n from formula (4) in the equation $dD/D = dC/C$, one obtains

$$dD_n = K/t_n \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

with

$$K = 1{\cdot}43 \cdot 10^{-6} \cdot D^2 \cdot g' \cdot h \quad . \quad . \quad . \quad (9)$$

in which dD_n, D, and h are in feet. Except for the different constant, a cumulative process of calculation exactly similar to that described above for circumferences leads to final diameters which in turn lead directly to a properly corrected table. Formulæ analogous to (2) and (3) may be written down immediately from (8) and (9), but these are not likely to be required.

Calculation on Volumes

These may be required when the original measurements are either diameters or circumferences. For diameters, substitution of the value of dD from formula (8) in the equation $dv/v = 2 \cdot dD/D$ leads to

$$dv_n = M/t_n \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

with

$$M = 2{\cdot}86 \cdot 10^{-6} \cdot D \cdot g' \cdot h \cdot v \quad . \quad . \quad . \quad (11)$$

in which D and h are in feet, the former no longer appearing as its square.

In this, as in any of the formulæ in this section, any desired unit of volume may be used for v, when dv_n is obtained in the same unit. The cumulative form of calculation may again be applied to obtain the expansion corrections, in any desired unit of volume, which should be applied to the capacities otherwise tabulated for each ring.

When circumferences have been strapped, corrections in terms of volumes may similarly be obtained for each ring from $dv/v = 2 \cdot dC/C$, this leading to

$$dv_n = P \cdot h_x/t_n \quad . \quad . \quad . \quad . \quad . \quad (12)$$

with

$$P = 9{\cdot}12 \cdot 10^{-7} \cdot C \cdot g \cdot v \quad . \quad . \quad . \quad (13)$$

Here v and dv_n may be taken in any one unit of volume, meanings of and units for the other symbols being as given with formula (2). The process of calculation also follows that given with formula (2), results being the volumes to be subtracted from the capacities of each ring, as calculated from the strappings, to reduce these to empty capacities. This is then followed by the restoration to each ring of the volumes, calculated cumulatively, from

$$dv_n = Q/t_n \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

with

$$Q = 9{\cdot}12 \cdot 10^{-7} \cdot C \cdot g' \cdot v \cdot h \quad . \quad . \quad . \quad (15)$$

the process used being exactly parallel to that described for formula (4), and the result a table corrected for expansion.

Metric Units

In these units, formula (2) becomes

$$dC_n = S \cdot h_x/t_n \quad . \quad . \quad . \quad . \quad . \quad (16)$$

with

$$S = 7{\cdot}63 \cdot 10^{-5} \cdot C^2 \cdot g \quad . \quad . \quad . \quad . \quad (17)$$

in which dC_n is the expansion in metres of the circumference C, also in metres, under a liquid head of h_x metres at a level in the tank at which the thickness in millimetres of the side-plates is t_n, g being the density in kilograms per litre of the liquid in the tank.

The metric formula corresponding to (4) is readily written down from (16) and (17). The cumulative method of calculation, and the various conversions from circumference corrections to those for diameters and volumes apply here also.

HYDRODYNAMIC LUBRICATION OF ROTATING DISCS IN PURE SLIDING

(*J. Inst. Petrol.*, 1951, **37**, 471–86.)

Corrections:

Page 482, line 10, should read:

$$= \iiint_V vp\rho \frac{\partial}{\partial x}\left\{\frac{1}{\rho}\right\} dxdydz \text{ (see Ramsey "Hydrodynamics," p. 376).}$$

Pages 483, line 7 from bottom, should read:

$$\text{so as } l \longrightarrow \infty, = -p \log . e^2 + \text{infinite constant.}$$

Additional Notes:

The author writes that he saw the papers by H. Blok and R. W. Dayton (*loc. cit.*) too late to comment on the method by which the oil film could be formed when the sliding discs are of identical size and material and rotating in pure sliding.

It is clear that the thermal properties of the discs are the same. Assume, however, that due to some chance irregularity there is a momentary temperature flash at one disc surface, such that the temperature of part of the contact zone of one disc will be greater than that at the other. This will cause the viscosity of the oil to drop there, and so most of the shear will take place at the hotter surface. This will cause a larger amount of heat to be generated there—the dissipation term being

$$\eta \left\{\frac{\partial u}{\partial y}\right\}^2$$

and hence the hot zone will be extended. Once the hot zone has spread it will be perpetuated, there being no cause for the process to be reversed, so one disc surface will run permanently hotter than the other.

This will then produce the asymmetry in the stream lines required to generate an oil film.

AUTHOR INDEX

ADAMSON, T., Correspondence on Bitumen, 270
AINSWORTH, J. A., on Safety Codes, 201
ASCHER, RICHARD, on Waxes, 308

BADDELEY, A. R. W. *See* GARNER, F. H.
BARR, K. W., The Jet Sampler—A Method of Obtaining Submarine Samples for Geological Purposes, 658
BARRETT, E. G. V., on Waxes 308, 309, 312
BATTCOCK, W. V., on Combustion Symposium, 569
BAXTER, A. D., on Combustion Symposium, 574, 575
BEAVEN, G. H., IRVING, R., and THOMPSON, C. N., A Method for Evaluating the Oxidation Stability of Inhibited Transformer Oils, 25
BIRCH, S. F., and McALLAN, D. T., The Separation of Sulphur Compounds by means of Mercuric Acetate, 443
BIRKS, J. *See* LAIRD, A.
BISKE, V., on Safety Codes, 203
——, on Stability of Mineral Oils, 59
——, on Standardization, 366, 367
BLOTT, J. F. T., on Standardization, 365
BLYTHE, R. H., on Waxes, 314
BOWEN, I. G., on Combustion Symposium, 567
BURRILL, J. W., on Safety Codes, 203

CAMERON, A., Hydrodynamic Lubrication of Rotating Disks in Pure Sliding. A New Type of Oil Film Notation, 471
CAWLEY, C. M., on Petroleum and European Recovery, 16
CHALLENGER, FREDERICK, and EMMOTT, ROBERT, Substitution Products of the Isomeric Thiophthens. The Structure of Liquid Thiophthen (Thiopheno-2′ : 3′ : 2 : 3 Thiophen), 396
CHEETHAM, H. A. *See* GARNER, F. H.
CHU, JU CHIN, How to Train Refinery Engineers in Distillation, 605
CRAWFORD, W., on Safety Codes, 203
CURRAN, M. J., on Waxes, 308, 315

DARBYSHIRE, B. N., on Petroleum and European Recovery, 23
DARWIN, SIR CHARLES, Memorandum on the Unit of Heat, 159
DAVIES, H. M., on Standardization, 364
DAWSON, J. G., Some Considerations on the Combusion of Gas Turbines, 509
DE WILDE, H., I.P. Safety Codes, Application to Drilling and Production, 181
DICKSON, M. R., Water in Transformer Oil—A Critical Résumé of the Causes and Effects of Water in Oil-filler Transformers, 373
DURHAM, J. S. *See* MAPSTONE, G. E.

EISMA, E., and KROM, C. J., *n*-Heptane as a Standard Solvent for the Asphaltene Determination in Asphaltic Bitumen, 582
ELLIS, E. G., The Work and Programme of Sub-Committee No. 12. Greases, 358
ELTENTON, G. C., on Spectroscopic Methods, 144
EMMOTT, ROBERT. *See* CHALLENGER, FREDERICK.
EVANS, R. F., and SMITH, J. C., Alkylnaphthalenes, Part VI. 1 : 3-Dimethylnaphthalene, 80

FRANKEL, P. H., on Petroleum and European Recovery, 23
FRASER, R. A., on Stability of Mineral Oils, 64
FREEBORN, A. S., on Stability of Mineral Oils, 63
FREMOUTH, R. M., on Stability of Mineral Oils, 63
FRIEDMANN, WALTER, Dehydrogenation of Tetrahydro-Thiopene Dithionethiophanes, 40
——, Note on Dimethyl-Dithienyl, 242

GARDNER, H., The Work and Programme of Sub-Committee No. 4. Gas, Diesel, and Fuel Oil, 352
GARNER, F. H., The Training of a Technologist, 663
——, and BADDELEY, A. R. W., Detergency of Carbon-Black Suspensions. Part III. In Toluene, 426
—— ——, and CHEETHAM, H. A., Flow Pattern of Gas Turbine Combustion, 554
——, ——. *See* also WILSON, B. S.
GARNER, P. J., The Work and Programme of Sub-Committee No. 9. Derived Chemicals, 357
GAUNT, T. N., on Waxes, 312
GODSAVE, G. A. E., on Combustion Symposium, 578

GROSSMITH, F., on Stability of Mineral Oils, 64

HAAK, F. A., and VAN NES, K., Investigation with the Olefinic Components of a Pennsylvanian Crude Oil, 245
HALEY, A. A., on Waxes, 314
HARTLEY, A. C., on Safety Codes, 197
HERINGTON, E. F. G., Tests for the Consistency of Experimental Isobaric Vapour-Liquid Equilibrium Data, 457
HOWGILL, D. R., on Safety Codes, 200
HUDSPETH, D. S., on Safety Codes, 201
HURLEY, T. F., The Design of Combustions Chambers for the Coal-Fired Gas Turbine, 517
HYDE, W. L., on Spectroscopic Methods, 138, 145

IRVING, R. *See* BEAVEN, G. H.
——, and THOMPSON, C. N., Diffusion as a Rate-Limiting Factor in the Oxidation of Transformer Oils, 67

JAGGER, H., Work and Programme of Sub-Committee No. 2. Crude Oil, 349

KELLY, C. I., on Petroleum and European Recovery, 21
KERR, PETER, Restraints on the Expansion of Vertical Tanks under Liquid Head, 209
——, The Expansion of Vertical Cylinders Under Liquid Head, 740
KINNER, G., on Standardization, 368
KREULEN, D. J. W., Stability Test of Motor Lubricants, 316
KROM, C. J. *See* Eisma, E.

LAIRD, A., and BIRKS, J., Performance and Accuracy of Amerada Bottom Hole Pressure Recorder with Special Reference to use in Drill Stem Formation Tests and Repeatability of Reservoir Pressures obtained Therein, 678
LEE, C. S., Geophysical Surveys of the Bahama Banks, 633

MACFARLANE, J. J., on Combustion Symposium, 573, 574, 575, 576, 578
MACKLEY, F., on Safety Codes, 197
MCALLAN, D. T. *See* BIRCH, S. F., 443
MAKOWER, A. D., on Spectroscopic Methods, 144
MAPSTONE, G. E., and DURHAM, J.S., Influence of Carbon Disulphide on Octane Number and Load Susceptibility, 737
——. *See also* MATHEWS, R. C.
——. *See also* NOTTES, G.
MARTIN, A. E., on Spectroscopic Methods, 140
MATHEWS, R. C., and MAPSTONE, G. E., Acid Treatment of Shale Gasoline, Part 1, Hydrolysis of the Acid Sludge, 147
MAYO, F., I.P. Safety Codes, Application to Refinery, 186
MAZEE, W. M., on Waxes, 305, 312
MENZIES, A. C., on Spectroscopic Methods, 143
MILES, P. F., on Petroleum and European Recovery, 19
MINCHIN, S. T., on Waxes, 310
MOERBEEK, B. H., on Standardization, 364, 371
MULLINS, B. P., on Combustion Symposium, 570, 574, 576, 578, 581
MUSKAT, M., Our Unproduced Reserves. What Are They? 717
MYDDLETON, W. W., The Stability of Mineral Oils in Toilet and Cosmetic Preparations, 45

NOTTES, G., and MAPSTONE, G. E., Studies in Shale Oil. Part 1. Some Properties of the Gas Oil Fraction, 259
NUTTALL, W. L. F., on Safety Codes, 200

OGLE, JOHN, Recent Developments in Test Methods for the Knock Rating of Aviation Gasoline, 431

PARKER, J. S., on Petroleum and European Recovery, 20
PEEL, D. H., on Standardization, 368
——, on Stability of Mineral Oils, 65
POHL, W., on Stability of Mineral Oils, 65
——, on Standardization, 365
PORTER, C. R., and WOOD, B., The Reaction of Dinitrogen Tri- and Tetr-oxides with Olefins. 2-Ethylbut-1-ene and Dec-1-ene, 388
PRACY, H. E. F., on Safety Codes, 201
PRICE, W. C., The Absorption Spectra of Molecules in the Vacuum Ultra-Violet, 106

RAMPTON, H. C., on Combustion Symposium, 575
RAWSON, E. S., on Stability of Mineral Oils, 65
——, on Waxes, 313
REYNOLDS, J. G., Some Criteria for Commerical Spectrometers, 125
——, Part II—Comments by Manufacturers, 588
RICHARDS, T., on Safety Codes, 204
RIDDELL, G. L., on Waxes, 305
ROGERSON, C. A. A., on Safety Codes, 200

SALOMON, T., on Waxes, 311
SAMUEL, D. L., on Standardization, 371
——, on Waxes, 303
SARGENT, E. H. G., on Waxes, 311
SARJEANT, R. L., I.P. Safety Codes, Application to Marketing, 192

SCHNURMANN, R., on Stability of Mineral Oils, 62
SCOTT, M. O., STANSFIELD, R., and TAIT, T., Fuels for Aviation and Industrial Gas Turbines, 487
SHEPPARD, N., The Infra-Red and Raman Frequencies of Hydrocarbon Groupings, 95
SMITH, E. A., Notes on the Lubricating Effect of Colloidal Graphite, 255
SMITH, J. C. *See* EVANS, R. F.
SMITH, VERNON, Petroleum and European Recovery, 2
SOUTHWELL, C. A. P., on Cadman Medal Presentation, 424
SPALDING, D. B., on Combustion Symposium, 576
SPECTROSCOPIC PANEL, Industrial Application of Absorption Spectroscopy, 109
STANSFIELD, R. *See* SCOTT, M. O.
STEVENSON, H. W., on Stability of Mineral Oils, 64
STURGESS, E. J., Model Code of Safe Practice in the Petroleum Industry, 163

TAIT, T. *See* SCOTT, M. O.
THOMAS, W. H., on Standardization, 370
THOMPSON, C. N. *See* BEAVEN, G. H.
——. *See* IRVING, R.
THOMPSON, H. W., on Spectroscopic Methods, 135
THORNYCROFT, O., on Petroleum and European Recovery, 18
THORPE, T. C. G., Petroleum Waxes: Their Use and Evaluation for Paper Packaging, 276
TOPPS, J. E. C., An Experimental Study of the Evaporation and Combustion of Falling Droplets, 535

UNDERHAY, G. F., on Waxes, 304, 315

VAN DE STADT, J. J., on Safety Codes, 199
VAN KERKVOORT, W. J., and NIEUWSTAD, A. J. J., Determination Dry-Sludge Content of Fuel Oils: Development of the Shell Hot Filtration Test (SHFT), 596
VAN NES, K. *See* HAAK, F. A.
VAN RIEMSDIJK, A. J., VAN STEENIS, J., and WATERMAN, H. I., Addition of Hydrogen Sulphide to *iso*Pentene with Aluminium Chloride as Catalyst, 265
VAN STEENIS, J. *See* VAN RIEMSDIJK, A. J.
VICKERY, D., on Waxes, 309

WADE, ARTHUR, Brief History of the Search for Oil in the Australian Commonwealth, 696
WARNER, F. E., on Safety Codes, 200
WATERMAN, H. I. *See* VAN RIEMSDIJK, A. J.
WEBB, A., on Waxes, 306
WHITBY, J. H., on Safety Codes, 203
WILSON, B. S., and GARNER, F. H., The Role of Peroxides in the Corrosion of Lead by Lubricating Oils, 226
WILSON, ROBERT E., Competitive and Co-operative Research in the Petroleum Industry, 407
WOOD, B. *See* PORTER, C. R.

NAME INDEX

Aepli, O. T., 629
Albat, —, 509
Alden, R. P., 609, 625
Allen, H. D., 628
Amundson, N., 615, 625
Anderson, B., 386
Anderson, J. S., 631
Anderson, J. W., 625
Andros, —, 653
Anson, H. A., 58
Arlis, D., 606
Armfield, F. A., 37, 39, 57, 58
Armstrong, B. F., 625
Arps, J. J., 695
Aschan, O., 264
Ashforth, G. K., 564, 566
Ashrof, F. A., 625
Aston, J. G., 629
Atkins, G. T., 623, 625

Bach, A., 39
Badger, W. L., 607
Bailey, A. S., 90
Bailey, E. V., 616, 617, 625
Baker, A. W., 625
Baker, E. M., 625, 628, 630
Baker, R. B., 43
Baldock, H., 395
Baldwin, R. R., 564, 566
Ball, L. C., 715
Balsbaugh, J. C., 374, 387
Barbaudy, I., 606
Barnes, R. B., 125
Barnett, B., 587
Barnett, E. B., 80, 90
Barr, J., 570
Bartky, W., 620, 625
Barton, C. H., 39
Batchelder, A. H., 604
Baryschewa, G., 405
Bavendamm, —, 653
Beatty, H. A., 615, 631
Beavan, G. H., 39, 375, 377, 387
Bebie, Jules, 625
Beckett, —, 610
Beckinsale, S., 385, 387
Beebe, A. H., 625
Bell, H. S., 607, 608
Bender, O. R., 604
Benedict, M., 621, 632, 625
Berg, C., 620, 625
Berg, L., 627
Bergström, —, 606
Bernhauser, K., 607, 625
Besson, L. R., 264
Beyer, C. M., 622, 625
Beyer, G. H., 625
Biegl, J., 625
Birch, A. J., 90
Biske, V., 39
Bisson, E. E., 258
Black, J. V., 385, 387
Blaize, R. N., 625
Blatchford, T. B., 716
Bliss, H., 625
Blunt, W. H., 387
Boatright, R. G., 625
Boer, H., 254
Bogart, M. J. P., 620, 625
Bogert, M. T., 80, 90
Bolle, W. L., 618, 619, 625
Bond, G. R., Jr., 254
Bonilla, C. F., 616, 625
Bonner, R. F., 631
Bonnet, W. E., 627
Booth, W. E., 625
Borel, J., 385, 387
Borrmann, C. H., 625
Bosnjakovic, F., 607, 625
Bost, —, 241
Boswell, B. C., 626
Böttcher, B., 43
Bowen, R., 627
Bowman, J. R., 57, 58, 630
Bowmann, J. R., 620, 625
Boyd, D. M., 623, 625
Boyd, W. T., 632
Bradford, J. R., 627
Bramhall, R. V., 443, 456
Brandt, R. L., 628
Braude, E. A., 109
Braun, W. G., 106
Bray, L., 625
Breger, I. A., 625
Bremner, J. G. M., 125
Brennecke, L. F., 609, 626
Briant, R. C., 620, 625
Broeder, J. J., 254
Brooks, R. F., 626
Brown, A. C., 625
Brown, G. G., 607, 609, 617, 618, 625, 631
Brown, H. Y. L., 715
Brownscombe, E. R., 679, 695
Bruno, B. P., 625
Bryant, K. C., 90
Bubb, F. W., 614, 629
Büche, W., 486
Bucher, J. B., 570
Buell, F. W., 625
Burwell, A. W., 386
Burwell, R. T., 486
Busche, R. M., 626
Buschman, W. J., 630

Calvert, J. F., 617, 627
Cameron, A., 477, 481, 686
Cameron, W. E., 715
Campion, M., 625
Cannon, M. R., 625
Carey, J. S., 625
Carlson, H. C., 625
Carne, J. E., 710, 716
Carney, T. B., 606, 626
Carpenter, J. H., 626
Carslaw, H. S., 483
Challenger, F., 396–405, 443, 456
Chaney, P. E., 695
Chase, J. L., 661
Chilton, T. H., 620, 626
Chu, J. C., 606, 609, 611, 614, 619, 620, 626, 627
Cicalese, J. J., 617, 626
Cicalese, M. J., 628
Clapham, P. H., 397, 398, 399, 400, 402, 405
Clapp, F. G., 709, 716
Clark, A. M., 458, 470
Clarke, J. S., 566
Claus, A., 90
Coates, J., 616, 617, 625
Coggeshall, N. D., 125
Cogle, J. E. T., 386
Colburn, A. P., 616, 620, 621, 625, 626
Collins, F. C., 626
Colthup, N. B., 125
Condit, D. Dale, 704, 716
Conn, A. L., 627
Connors, J. S., 629
Conway, R., 625
Cook, G. B., 626
Cooper, H. B. H., 626
Cooper, W. F., 387
Cope, J. G., 629
Corn, L. H., 616, 626
Cornwell, P. W., 628
Cosway, R., 632
Coull, J., 630, 632
Coulon, D. R., 679, 695
Coulson, E. A., 458, 467, 470
Coulter, K. E., 625
Coursey, —, 377
Cox, E. G., 397, 405
Cubbage, T. L., 625

Daly, E. F., 125
Dauphine, T. C., 618, 626
Davenport, J. E., 387
Davidson, V. M., 631
Davies, J. A., 626
Davies, M., 606
Day, J. H., 238
Dayton, R. W., 486
Delany, W. H., 631
Dempster, A. J., 620, 625
Denison, G. H., 238
Denmead, A. K., 715
Denzler, C. G., 622, 629
Dewees, E. J., 682, 684, 695
Diamond, H., 30, 39
Dimroth, O., 81, 90
Dinerstein, R. A., 264
Dixon, O. G., 625, 626
Diouky, G., 238
Dmytryszn, M., 611, 626
Dobratz, C. J., 626
Dodds, D. L., 626
Dodge, B. F., 607, 625, 626
Doll, D. P., 626
Donnell, C. K., 627
Donovan, J. R., 626
Dornte, R. W., 374, 377, 378, 386
Doss, M. P., 609
Dresser, T., 631
Drew, —, 653
Drickamer, H. G., 622, 627
Dufraisse, C., 33, 39
Duhamel, J., 629
Duncan, D. W., 627
Dunlop, A. K., 264
Dunn, C. L., 627
Dushmann, Saul, 627
Duwey, P., 553
Dye, W. S., 630

Eastman, D., 628
Ebert, —, 610
Eccleston, B. H., 631
Eckert, —, 536, 553
Edgeworth-Johnstone, R., 620, 627
Edmister, W. C., 606, 627
Egerton, A. C., 563, 566
Ehmann, L., 90
Eilers, H., 582, 587
Elliot, C., 606
Emmott, R., 397, 398, 399, 400, 402, 405
Engelburger, J. F., 595
Englahl, R. B., 627
Eshaya, A. M., 627
Eucken, A., 607
Evans, R. N., 387
Ewell, R. H., 621, 624, 627
Ewing, M., 639, 646, 657

Failey, C. F., 632
Fansek, A. J., 627
Fansek, I. F., 627
Farmer, E. H., 39
Feldman, J., 627
Fellgett, P. B., 106
Fenske, M. R., 106, 615, 624, 627
Ferguson, C. V., 374, 377, 378, 386
Fidler, F. A., 443, 456
Field, —, 653
Field, R. M., 641, 643, 657
Fieser, L. F. 90
Fisher, A. W., 627
Fleming, —, 661
Fletcher, B. J., 627
Fleury, P., 395
Forrest, J., 90
Forrest, J. S., 385, 387
Forsythe, W. L., 627
Foster, L. F., 39
Fowler, F. C., 627
Fowler, R. T., 627
Francis, A. W., 627
Fred, M., 245, 246, 247, 254
Frey, D. R., 238
Friedman, B. S., 269
Friedmann, W., 43, 241
Frieland, D., 621
Friend, L., 629
Frity, A. Robinson, 316, 318, 323
Frössling, N., 536, 553
Fuchs, N. V., 553
Fuhrmeister, L. C., 626
Furnas, C. C., 627, 631
Fussman, F., 631

Gable, C. M., 264
Galindo, H. F., 604
Gallagher, G. G., 627
Gardner, H. S., 619, 627
Garwin, L., 627
Gay, L., 606
Gaynor, —, 233
Geddes, R. L., 627
Gelus, E., 627
Gemant, A. L., 386
George, P., 33, 34, 39, 75, 79, 387
Gerster, J. A., 627
Getty, R. J., 609, 626
Gibbons, —, 500, 509
Gibson, G. M., 396, 401, 403, 404, 405
Gillies, J. F., 385, 387
Gilliland, E. R., 606, 607, 616, 617, 627, 630
Gillott, R. J. J. H., 397, 405
Gilmont, R., 627, 630
Givens, H. C., 627
Glasgow, A. R., 90
Godfrey, D., 258
Godsave, G. A. E., 579
Goetz, G. W., 617, 627
Golay, M., 134
Goldfarb, I., 405
Good, A. J., 618, 619, 627
Gooding, R. M., 631
Gordon, A. R., 468, 470
Gordon, D. H., 627
Gordon, R. R., 125
Gore, R. C., 125
Gossling, P. W. L., 387
Gould, C. W., 627
Grassman, P., 627
Greenfield, S. H., 622, 629
Griswold, J., 627
Grohse, E. W., 627
Grue, W. A., 607
Gumz, —, 536, 543, 553
Gurwitsch, L., 264

Haase, R., 628
Hadden, S. T., 628
Haldenwanger, H., 628
Hales, J. L., 467, 470
Halford, R. S., 595
Hall, M. W., 628
Ham, A. J., 26
Hancock, R. A., 90
Hansford, R. C., 43
Happel, J., 622, 628
Harbert, W. D., 616, 617, 628
Harding, —, 264
Haresnape, D., 443, 456
Harris, G. P., 106
Harrison, J. B., 397, 398, 400, 402, 405
Harrison, J. M., 627
Harrison, Lord, 595
Hashmall, F., 627, 629
Haslan, J., 443, 456
Hauer, H. J., 627
Hausbrand, E., 606
Headington, C. E., 629
Heath, —, 509
Heertjees, P. M., 387
Heilbron, I. M., 90
Helwig, R. W., 626
Hemm, R. V., 626
Herington, E. F. G., 458, 463, 467, 470
Heron, A., 564, 566
Herrington, P. J., 619, 626, 628
Hess, H., 643, 648, 657
Hess, I., 627
Hickinbottom, W. J., 264
Hickman, K. C. D., 624, 628
Higley, W. S., 264
Hildebrand, J. H., 607, 628
Hill, A. V., 595
Hillman, E. S., 587
Hills, C. W., 628
Hilsmittel, —, 607
Hiral, H., 387
Hirschfelder, J. O., 468, 470
Hlinak, E. L., 626
Hobbie, A. C., 624, 628
Hobson, R. A., 716
Hodgman, C. D., 609
Hodgson, M. A. E., 628
Hoffert, W. H., 269
Holbrook, G. E., 628
Holder, C. H., 628
Holloway, F. A. L., 631
Holzman, George, 627
Hornibrook, W. J., 468, 470
Horsley, L. H., 609, 610, 622, 628, 629
Houben, J., 607, 628
Hougen, O. A., 470, 607, 609, 628
Houghland, G. S., 626,
Howes, D. A., 509
Hsu, K. H., 626
Huang Minlon, 90
Hubner, H. J., 566
Huffman, J. R., 620, 628
Hufnagel, J. A., 628
Hulschison, K. E., 627
Hulse, S. H., 599, 604
Human, J. P. E., 628
Hummel, H. H., 616, 622, 627, 628
Huntington, C. R. B., 628
Huntington, R. I., 630
Huntington, R. L., 625
Hurworth, H., 79, 377, 387
Hutchinson, A. J. L., 626
Hutchinson, M. H., 627

Illing, L. V., 652
Ipatieff, V. N., 269
Irlin, A. L., 628
Irving, R., 39, 375, 377, 387

Jackson, C. A., 630
Jackson, M. L., 628
Jacobs, J. J., 630
Jacobs, M. B., 628
Jaeger, J. C., 483
Jaeger, R., 90
Jaffe, —, 610
Jakob, M., 607
James, I. J., 620, 625
Jantzen, E., 606
Jeffery, G. A., 397, 405
Jellinek, H. H. G., 58
Jennings, A. S., 626
Jenny, F. J., 616, 617, 628, 380, 631
Jensen, H. I., 715
Jitkow, O. N., 80, 90
Johnson, —, 661
Johnson, R., 258
Johnson, R. C., 630
Johnstone, H. F., 628
Jonash, —, 500, 509
Jones, —, 493, 509
Jost, W., 509, 563, 566, 628
Justi, E., 609

Kaiser, R. R., 628
Kania, —, 657
Kapff, S. F., 57, 58
Karnotsky, George, 617, 628
Katy, D. L., 609, 625, 628
Kay, W. C., 629
Keeson, W. H., 606
Kellogg, A., 609, 628
Kemp, A. P., 42, 43
Kemp, H. S., 628
Kennedy, H. C., 39
Kennedy, R. B., 626
Kennedy, R. M., 627
Keyes, D. B., 628
Khambda, O. P., 626
Kilpatrick, —, 610
Kincannon, C. B., 628
King, —, 125
King, L. C., 399, 405
Kinney, C. R., 631
Kirkbride, C. G., 618, 628
Kirschbaum, E., 606, 628
Kister, A. T., 630
Kistyakowskii, V. A., 628
Kitchen, —, 125
Klein, V. A., 628
Klevens, H. B., 109
Klit, A., 606
Kloetzel, M. C., 80, 90
Ko, T. L., 628
Koch, F. C., 628
Koebner, A., 90
Koenigs, E., 157
Koffalt, J. H., 629
Kooyman, E. C., 254
Korb, E. L., 604
Kossatz, R. A., 629
Kraft, W. W., 628
Kramer, F., 627
Kramers, H., 254
Kreig, A., 623, 629
Kretschmer, C. B., 470
Kreulen, D. J. W., 54, 58, 323, 375, 387
Kreulen Van Selms, F. G., 54, 58, 323, 387
Krieger, M., 36, 39, 387
Krollpfeiffer, F., 90
Kuenen, J. P., 607
Kullenberg, B., 661
Künzler, H., 316, 323

Lacet, M., 609
Lacey, W. N., 610, 630
Lake, G. R., 628
Lamb, G. G., 629
Lamb, John, 604
Lane, W. R., 538, 553
Langdon, W. M., 628
Lange, J., 395
Lange, N. A., 610
Larsen, R. G., 37, 39, 57, 58, 79, 238, 387
Latchum, J. W., 629
Laurent, Pierre, 629
Leedy, —, 639
Leffler, M. T., 90

Lein, A. P., 264
Lessing, R., 629
Levine, —, 610
Levy, N., 395
Levy, S., 609
Lewis, W. K., 607, 629
Leyes, C. E., 629
Liander, H., 79, 387
Licht, W., 622, 629
Lindsay, R. A., 625
Linnel, W. H., 629
Lipman, —, 653
Lippincolt, S. R., 629
Lloyd, L. E., 629
Lloyd, P., 578
Loane, —, 238
Lobo, W. E., 629
Lock, J. J., 387
Lockhardt, F. J., 625, 629
Loofbourow, —, 595
Love, A. E. H., 483
Lowry, A., 57, 58
Lowry, R. A., 443, 456
Lüder, J., 387
Luke, C. D., 629
Lüttringhaus, A., 43
Lyman, M. M., 629

McAdams, W. H., 607
McCabe, W. L., 607
McCarthey, R. F., 627
McClanahan, H. J., 626
McClatchey, H. E., 623, 629
McClure, F. T., 468, 470
McCormick R. W., 106
McEwen, Ewen, 486
McHeill, E., 264
McKee, S. A., 316, 318, 323
McKittrick, D. S., 629
McMahon, H. O., 620, 629
McMillan, A., 90
Madorsky, S. L., 629
Mair, B. J., 80, 90
Maitland, A. Gibb, 710, 716
Manning, E., 627, 628
Mapstone, G. E., 157, 264, 456
Marder, M., 607, 608, 629
Mariller, C., 606
Marple, S., 627
Marschner, R. F., 264
Marshall, W. R., 620, 629
Martin, H. M., 486
Martin, H. Z., 617, 625
Massey, L., 387
Masson, E., 378, 385, 386
Matheson, G. L., 629
Mattix, E. D., 629
Mauritz, F. E., 387
Maxwell, J. B., 610
May, J. A., 616, 629
May, K. R., 566
Mayfield, F. D., 616, 629, 631
Mayor, —, 651
Medcalf, E. C., 626
Meissner, H. P., 622, 629
Meipolder, F. W., 629
Merritt, H. E., 472, 486
Meyer, F., 387
Middleton, J. F., 632
Miles, F. T., 629
Millar, R. W., 264, 627
Miller, A. W., 264
Miller, E., 627
Miller, S. A., 397, 403, 405
Minard, G. W., 629
Minich, H. L., 630
Mitchell, F. W., 629
Mitchell, J. S., 125
Mochel, J. M., 470
Moder, J. J., 611, 626
Montross, C. G., 616, 631
Moore, H., 264
Morel, F., 258
Morrell, S. H., 90
Morris, J. W., 627
Morris, R. C., 629
Morris, W. L., 629
Morton, A. A., 607, 629
Motzkus, E., 269
Moureu, C., 33, 39
Mueller, N. F., 626
Muhr, F., 90
Muller, G., 79, 373, 374, 375, 377, 386
Mullins, B. P., 570
Munter, P. A., 629
Murdoch, P. G., 629
Murphy, E. T., 90
Murray, J., 651, 657
Muskat, M., 695
Myers, H. S., 627
Myles, M., 627

Naul, M., 629
Nehbel, H., 606
Nelson, W. L., 607, 629, 632
Nickel, E., 54, 58
Niemann, Carl, 627
Norman, W. S., 629
Norton, —, 241
Nutting, H. S., 622

Oberfell, G. G., 609, 625
O'Gorman, J. M., 629
Okamoto, K. K., 629
Okes, Walter, 707
Olds, R. H., 630
Oncley, J. L., 387
Onslow, D. V., 79, 378, 386
Opler, A., 617, 629
Orchin, M., 627
Othmer, D. F., 613, 621, 627, 629, 630, 631
Otto, C., 630
Overbeck, R. L., 611, 626
Ower, E., 566

Parker, F. D., 630
Patterson, T. S., 90
Paul, R., 606, 609, 626
Pauling, L., 397, 405
Peary, C. C., 630
Peck, E. B., 630
Penther, C. J., 630
Peppler, W., 486
Perkins, H. W., 695
Perktold, Franz, 630
Perry, E. S., 630
Perry, J. H., 607, 630
Peters, E. D., 227, 238
Petrie, J. M., 264
Pfeiffer, J. Ph., 604
Phillips, J. C., 621, 626
Pierotti, G. J., 627
Pigford, R. L., 628
Piret, E. L., 628
Platt, J. R., 109
Podbielniak, W. J., 630
Poettmann, F. H., 614, 630
Poffenberger, N., 630
Pohl, W., 26
Pollitt, A. A., 25, 39, 69, 79, 377, 387
Pompeo, D. J., 630
Popovac, D. O., 625
Porter, C. A., 628
Powell, H., 125
Powell, M. J., 628
Powick, M., 54, 58
Powling, J., 563, 566
Prahl, W., 606
Prandtl, L., 543, 553
Prevost, C., 617, 630
Price, W. C., 109
Probert, R. P., 578, 580
Prutton, C. F., 238
Puck, T. T., 632
Pull, D. J., 630
Pusson, —, 657
Putscher, R., 245, 246, 247, 254
Pyle, C., 628
Pyott, W. T., 630

Quiggle, D., 106, 627

Raggatt, H. G., 716
Rakowsky, G., 405
Rampton, H. C., 509
Ramsay, A. S., 486
Randall, —, 125
Rank, D. H., 106
Ranney, Leo, 699
Rasmussen, H. E., 43
Raymond, C. L., 468, 470
Reamer, T. E., 79
Reavell, J. A., 630
Rechenberg, C. V., 606
Redlich, O., 264, 630
Reeves, Frank, 704, 709, 710
Reid, E. E., 43
Reid, J., 715
Reilly, J., 606
Revukas, A. J., 387
Reynolds, O., 543, 553
Rheinboldt, H., 269
Rhys, C. O., 630
Ricciardi, L. G., 630
Richard, A. L., 630
Rideal, E. K., 33, 34, 39, 75, 79, 387
Rieder, R. M., 630
Robertson, A., 33, 34, 39, 75, 79, 125, 387
Robinson, C. S., 606
Robinson, R., 90
Robinson, W. D., 626
Robu, I., 598, 604
Robu, L. V., 630
Roffolt, J. H., 627
Roger, M. C., 618, 630
Rohr, K., 661
Rolfson, F. B., 630
Romanet, R., 630
Roper, C. G., 595
Rose, A., 606, 617, 620, 630
Rosendahl, F. A., 630
Rossini, F. D., 90, 610, 632
Roszkowski, E. S., 630
Rousseau, W. C., 618, 627,
Rubin, L. C., 621, 625
Rupert, C. S., 134
Ruzicka, L., 90
Rzasa, M. J., 600, 628

Sachanen, A. N., 43, 254, 264
Sage, B. H., 610, 630
Salomon, T., 377, 386
Sandberg, C. R., 630
Sanders, F. G., 80, 90
Savitsky, A., 595
Scaife, C. W., 395
Schäfer, W., 90
Schaffner, R. M., 630
Scheibel, —, 606
Scheibel, E. G., 616, 617, 621, 630, 631
Scheule, H. J., 604
Schlegel, F. A., 631
Schlessman, C. H., 631
Schoenborn, E. M., 626
Schomaker, V., 396, 405
Schoorl, N., 614, 631
Schuchert, —, 641, 646, 657
Schult, H. C., 631
Schultz, G. G., 605
Schumacher, R., 631
Schurig, W. G., 630
Schutte, A. H., 628
Schwartz, F. G., 631
Scientific Development Co., 631
Scofield, R. C., 631
Scott, R. L., 607, 628
Scratchard, G., 468, 470
Sears, —, 125
Sedlak, V. A., 632
Seglin, L., 631
Selbeimer, C. W., 631
Selker, M. L., 42, 43
Shaw, C. R., 78, 79

Sheppard, F. R., 661
Sherwin, D. S., 631
Sherwood, T. K., 632
Sherwood, T. R., 631
Shipley, G. H., 631
Shiras, R. N., 627, 631
Sidgwick, —, 254
Simpson, D. M., 106
Sitar, I. J., 629
Skeble, A. J., 606
Skolnik, H., 622, 631
Slotte, K. F., 475, 486
Smith, —, 653
Smith, A. E. W., 395
Smith, D. A., 631
Smith, D. C., 106
Smith, J. C., 90
Smith, K. A., 631
Smith, R. B., 631
Smith, R. H., 227, 238
Smith, R. L., 631
Smith, R. V., 682, 684, 695
Smith, T. R., 631
Smoker, E. H., 615, 620, 631
Solomon, E., 631
Somerville, R., 90
Somley, E. R., 629
Sommerman, G. M. L., 377, 387
Sorel, E., 607
Sorgato, I., 631
Souders, M., 618, 627, 631
Stack, T. G., 627
Stadnikow, G., 398, 405
Stäge, H., 605
Stage, V. F., 624, 631
Stäger, H., 316, 323
Stanley, Evan, 710
Starr, C. E., 631
Stearns, R. F., 620, 626
Stevens, D. R., 607
Steward, D., 264
Stewart, J., 264
Stigger, E. K., 632
Still, C., 631
Stoppel, A. E., 631
Storrow, J. A., 620, 631
Stout, L. E., 625
Strieff, A. J., 90
Strong, J., 134
Struck, R. T., 631
Stull, D. R., 610, 631
Šturza, F., 90
Suen, T. J., 615, 631
Suess, —, 646, 657
Sundralingham, A., 39
Surowiec, A. J., 631
Suter, H. H., 661
Sutherland, G. B. B. M., 106, 125
Sverdrup, —, 661

Tanner, E. M., 90
Tausz, J., 386
Taylor, —, 610
Taylor, M. L., 627
Temple, —, 125
Ten Eyck, E. H., 630
ten Have, C. D., 387
Ten Horst, D. Th. J., 385, 387
Termini, D. J., 90
Thaker, —, 630
Thiele, E. W., 618, 630
Thierry, E. H., 443, 456
Thomas, W. A., 631
Thompson, —, 125
Thompson, A. R., 630
Thompson, C. N., 26, 39, 375, 377, 387
Thompson, G. W., 631
Thomspon, H. W., 106, 125
Thompson, W. H., 385, 387
Thomson, G. W., 615, 631
Thormann, K., 614, 631
Thorpe, R. E., 37, 39, 57, 58
Thwaites, A. L., 599, 604
Tiller, F. M., 615, 631
Tivy, V. V. St. L., 623, 632
Tom, P. S., 615, 631
Trencham, —, 377
Trillat, J. J., 258
Tucker, S. H., 90
Tunescu, R. C., 632
Tung, C. C., 626
Tunnicliff, D. D., 595
Turbin, K., 627
Turner, —, 241
Twenhofel, W. H., 657

Ullmann, F., 607
Underwood, A. J. V., 615, 616, 617, 632
Universal Oil Products, 632
Urey, H. C., 620, 626
Utti, K. D., 632

Vago, E. E., 90
Van der Minne, J. L., 323
Van Dijck, W. J. D., 632
Van Dongen, J. R. J., 632
Vanghan, —, 651, 653
Van Nes, K., 254
Van Western, H. A., 56, 58, 254
Van Winkle, M., 629
Vellinger, E., 79, 375, 387
Vernon, L., 626
Veseley, V., 90
Vilbrandt, F. D., 605
Vlughter, J. C., 56, 58
Vogel, A. I., 254
Von Fuchs, G. H., 30, 39
von Karman, T., 543, 553
Voskuil, J., 598, 604

Wade, Arthur, 710, 711, 715, 716
Wagner, C. D., 227, 238
Walkden, J., 443, 456
Walmsley, —, 385
Walsh, A. D., 109
Walsh, T. J., 626
Walter, J. F., 632
Wang, S. L., 626
Ward, C. C., 607
Ward, L. K., 715
Waterman, H. I., 56, 58
Waters, M., 387
Watson, E. A., 566
Watson, K. M., 607, 609, 625, 625, 632
Way, S., 486
Weeks, I. F., 468, 470
Weihe, D. L., 626
Weinberger, L. N., 632
Weinman, E. A., 627
Weissberger, A., 607
Weitkamp, A. W., 264
Welch, L. M., 627
Welsh, L. H., 387
Welshans, L. N., 630
Wender, I., 627
Wendtner, K., 269
Wentworth, T. O., 630
Werkstoffe, —, 607
Wernecke, A., 632
Werner, —, 610
Weshaver, J. W., 632
Westernhagen, Matilda, 625
Wygand, C., 607, 608, 632
Whally, M., 90
Wheeler, D. H., 228, 238
Wheeler, H., 553
Whiffen, D. H., 106
White, B. C., 632
White, G. E., 632
White, R. R., 632
Whitehead, J. B., 385, 386
Whitehead, S., 386
Wiegand, R. V., 106
Wilde, H. D., 629
Wilke, C. R., 269
Wilkinzon, D. G., 90
Willgerodt, C., 90
William, E. B., 632
William, P. E., 632
Williams, —, 610
Williams, B., 629
Williams, G. C., 556, 566, 632
Williams, T. J., 617, 630
Williams, V. Z., 125, 134
Williamson, C. J., 621
Willingham, C. B., 90, 632
Willis, H. A., 106
Wilson, B. D., 620, 631
Wilson, G. W., 631
Wise, H., 632
Withrow, J. R., 627, 629
Woerner, R. C., 621,
Wohl, Kurt, 632
Wolf, A., 39
Wolf, J. E., 627
Wolfhard, H. A., 566
Wood, S. E., 470, 632
Wood, W. L., 477, 486
Woodfield, —, 622
Woodard, S. W., 635, 657
Wood-Mallock, J. C., 37, 39 57, 79, 385, 387
Woronzoq, J. J., 607
Worstall, R. A., 264
Wren, G. B., 630
Wride, W. J., 269

Yang, W. J., 626
Yellot, J. I., 523
Young, S., 607
Yu, K. T., 632
Yule, J. A. C., 58

Zawadiski, J., 467, 470
Zen, F., 629
Zimmerschied, W. J., 264
Zürcher, M., 387

SUBJECT INDEX

Acetylenes, spectra, 98
Alkylnaphthalenes, 1 : 3-dimethylnaphthalene : 80
  infra-red spectra, 89
  ultra-violet spectra, 87
Amerada bottom hole pressure recorder, 678
Aniline points : 62
  classification, 54
API Reserves Committee, 719
Aromatics, infra-red and Raman spectra, 103
Asphaltene determination *n*-heptane as standard solvent, 582
Australia :
  Northern, 712
  South, 708
  Victoria, 700
  Western, 709

Bahama Banks, geophysical surveys, 633
Bitumen :
  asphaltene determination using *n*-heptane, 582
  preparation for penetration test, 270
Brame, Prof. J. S. S. Installation as Honorary Fellow, 347
Bromine number, 54, 60
3 : 3-dimethylbutene-1, spectra, 98

Carbon black, detergency of, suspensions in toluene, 426
Centralia-Salem field, waterflooding, 722
Combustion :
  evaporation and, of falling droplets, 535
  flow pattern of gas turbine, 554
  in gas turbines, 509
  problems in industrial gas turbines, 503
  process in aero turbines, 495
  symposium, reactions in relation to gas turbine practice, 487
Corrosion :
  in acid treatment of shale gasoline, 151
  inhibition, by shale tar bases, 153
  of lead by lubricating oils, 225
  problems, in industrial gas turbines, 507
C.R.L. Teddington, standard samples, 125
Crude oil :
  IP Sub-Committee No. 2, 349
  Pennsylvanian, olefinic components of, 245

Dehydrogenation :
  of tetrahydrothiophene, 239
  of tetralin, 85
Derived Chemicals, IP Sub-Committee No. 9, 357
Detergency of carbon black suspensions in toluene, 426
Dimethyl-dithienyl, 242
Distillation :
  literature on, 605–10, 625–32
  training refinery engineers in, 605
Dithionethiophanes : 40–3
  crystallographic structures, 42
  spectral data, 42
Drilling, IP Safety codes, 181

Engine fuels, aero turbine, specifications, 488
Equilibrium, isobaric vapour–liquid, 407
Europe :
  fuel oil outlook, 11
  Marshall Plan in, 7–24
  new agricultural methods, 9
  new industrial developments, 12
  OEEC aspects, 7–24
  refining in, 6
  sources of oil supply, 4
  transport, 7, 10,
Exploration, history of Australian, 698

Fuel oils :
  aero turbine combustion-chamber deposits, 501
  dry-sludge, determination, 596
  Shell hot filtration test, 599

Gas, Diesel and Fuel Oil, IP Sub-Committee No. 4, 352
Gas injection, trials in W. Texas, 734
Gas oil, from shale oil :
  properties, 261
  treatment with acids, 260
  treatment with urea, 262
Gas turbines :
  coal-fired :
    "cyclone" combustion chambers, 532
    design of combustion chambers, 517
    film-cooled combustion chambers, 522
    refractory chambers, 528
    slurry-fired combustion chambers, 527
    "vortex" combustion chambers, 530
  flow pattern of, combustion, 554
  fuels for aviation, 487
  fuels for industrial 502
  industrial, corrosion problems, 507
  some condiderations on the combustion in, 509
Gasoline :
  aviation, knock rating developments, 431
  lead susceptibility, influence of carbon disulphidore on, 737

Gasoline—*cont.*
Octane No., influence of carbon disulphide on, 737
safety precautions, 170
shale, acid treatment, 147–57
Gasoline vapour, extent of danger area, 172
Geological surveys, jet sampler for submarine, 658
Geophysical surveys on the Bahama Banks, 633
Greases, IP Sub-Committee No. 12, 359

Heat :
memorandum on the unit of, 159
unit of, 158
n-heptane, for asphaltene determination, 582
2 : 2-dimethylhexane, spectra, 103
Hydraulic fluids, spectroscopic detection and determination of contaminants, 115
Hydrocarbon groupings, infra-red and Raman frequencies, 95–106
Hydrocarbons :
olefins, reaction of dinitrogen tri- and tetra-oxides with, 388
standard samples, 125
thiophthen, structure of liquid, 396
1 : 3-dimethylnaphthalene synthesis, 80

Institute of Petroleum :
Annual General Meeting, 337–43
Cadman medal, presentation, 424
Council Report, 1950, 324
Hon. Fellowship presentation to J. S. S. Brame, 347
Redwood medal, presentation, 276
Redwood lecture, 663
Sub-Committee :
No. 2, Crude Oil, 349
No. 4, Gas, Diesel and Fuel Oil, 352
No. 9, Derived Chemicals, 357
No. 12, Greases, 358
Symposium on spectroscopic methods, 93–146
Third Cadman Memorial Lecture, 407
Isoprenes, polymeric, spectra, 100

Jet sampler for submarine work, 658

Knock rating :
development of :
rich-mixture methods, 431
weak-mixture methods, 438
developments, 431
reference fuel scales, 441

Lead susceptibility, influence of carbon disulphide on, 737
Lub oils :
acidity, determination, 227
motor, stability test of, 316
peroxides, determination, 227
role of peroxides in corrosion of lead by, 225
Lubricating effect of colloidal graphite, 255
Lubrication :
colloidal graphite in, 255
hydrodynamic, new type of oil film formation, 471

Marketing, IP safety codes, 192
Measurement :
calculations, 742
correction of strapping to empty circumferences, 742
strapping conditions and calculations, 741
Mercaptans, 266, 447, 454
Mineral oils :
aniline points as means of classification, 54
fluorescence, 55, 59
influence of aromatics on stability, 56
laboratory oxidation, 52
non-carcinogenic mule-spinners oil, 64
peroxide value, 60–1
peroxide value, determination, 52
ring analysis, 56
stability, in toilet and cosmetic preparations, 45–66
stability of emulsions, 48
ultra-violet spectra, 57, 62

Naphthenes, infra-red and Raman spectra, 105
New Guinea, 716
New South Wales, 702
Nitroparaffins, infra-red transmission curves, 117

Obituary :
Brownlee, R. P., 406
Carder, R. A., 344
Dick, W. B., 344
Kewley, J., 272
Le Mesurier, L. J., 662
Lepper, G. W., 91
Satchell, E. A., 271
Wade, A., 273
Octane No., influence of carbon disulphide on, 737
Oil in the Australian Commonwealth, 698
Oklahoma, compulsory unitization law, 731
Olefins :
determination, chemical methods, 253
isolation by chromatography, 253
reaction of dinitrogen tri- and tetra-oxides with, 388
spectra, 99
types of, detectable by infra-red spectroscopy, 246
Oxidation :
of transformer oils, diffusion in, 67
stability :
of mineral oils, 45–66
of transformer oils : 25–39

Papua, 712
Paraffin wax. *See* wax, paraffin.

Paraffins, infra-red and Raman spectra, 102
Petrolatum :
*iso*Pentene, addition of hydrogen sulphide to, 265
spectroscopic evaluation of, as sunburn preventives, 119
visible and ultra-violet transmission characteristics, 120–2
Petroleum, and European recovery, 2
Peroxide number, 52, 61
Petroleum industry, Competitive and Co-operative Research in the American, 407
Production :
fluid injection, 723
secondary recovery in Trinidad, 732
water drive, 734
Production of petroleum IP safety codes, 181

Queensland, Australia, 704

Redwood lecture, 663
Redwood metal, presentation, 676
Refining :
acid treatment of shale gasoline, 147
IP safety codes, 186
spectroscopic examination of plant streams, 122
Reserves :
developments in E. Texas and Bayway fields, 724
problems and developments in, 718, 723
U.S. unproduced, 717

Safety precautions :
gasoline, data, 170–81
in refining, 186
IP codes, 181–97
in tank filling, 164
loading and unloading, 164, 189
model code of, 163
Shale oil :
corrosion by hydrolysed acid, 151
properties of gas oil fraction, 259
Shell hot filtration (sludge) test, 596
Spectra :
absorption, of molecules in the vacuum ultra-violet, 106–9
infra-red 1 : 3-dimethylnaphthalene, 89
ultra-violet 1 : 3-dimethylnaphthalene, 87
Spectrometers :
Grubb Parsons, 141
some criteria for commercial : 125
manufacturers' comments, 588
Spectrometry :
infra-red, Creitz Committee records, 139
standard samples, 125
Spectroscopic methods, symposium, 135–46
Spectroscopy :
absorption :
continuous examination of plant streams, 122
industrial applications, 109–25
Spectroscopy—*cont.*
infra-red :
characteristic absorption bands, 113
types of olefins detectable by, 246
IP symposium, 93–146
Standardization, IP symposium on, 349
Storage tanks, restraints on the expansion of vertical tanks under liquid head, 209
Sulphur compounds : 40, 239, 242, 265, 396, 443
recovery, 445, 448
separation, by mercuric acetate : 443
effect of mol. wt. on, 446

Tanks :
expansion of, 740
gas freeing precautions, 165
Tasmania, Australia, 702
Thiophens : 477, 454
isomeric substitution product, 396
structure of liquid, 396
Thymol, spectroscopic determination of an isomer, 116
Tetrahydrofurfural dimer, spectroscopic investigation, 118
Tetrahydrothiophene, dehydrogenation of, 239
Tetralene, dehydrogenation, 85
Training of a technologist, 663
Transformer oils :
diffusion as a rate-limiting factor in the oxidation of, 67–78
evaluation method, 25–39
sludge test and results, 68
variation in oil type, 70
variation in catalyst concn., 73
variation in catalyst type, 76
Transformer oils, inhibited, oxidation stability :
catalyst, 27
causes and effects of water in, 373
comparison of the two oxidation tests, 37
inhibitor efficiency, 35
inhibitor response, 32
inhibitor susceptibility, 30
Transformers, causes and effects of water in oil-filled, 373

United States, unproduced reserves, 717

Vapour–liquid equilibrium data, tests for consistency of isobaric, 457
Victoria, Australia, 700

Wax :
paraffin :
oil content, 299
tensile strength, 289
water-proofness and wet strength, 288
petroleum :
moisture-vapour permeability, 286
use and evaluation for paper packaging, 275
Wilson, R. E. Third Cadman Memorial Lecture, 407

JOURNAL OF THE INSTITUTE OF PETROLEUM

Honorary Editor
F. H. GARNER, O.B.E., Ph.D., F.R.I.C., F.Inst.Pet.

Honorary Associate Editor
E. B. EVANS, M.Sc., Ph.D., F.R.I.C., F.Inst.Pet.

Editor
GEORGE SELL, F.Inst.Pet.

VOLUME THIRTY-SEVEN
1951

Published by
THE INSTITUTE OF PETROLEUM
MANSON HOUSE,
26 PORTLAND PLACE,
LONDON, W. 1.

THE INSTITUTE OF PETROLEUM

(Founded 1913 as The Institution of Petroleum Technologists)

Past-Presidents

1914–1916	Sir Boverton Redwood, Bart., D.Sc., F.R.S.E. (died 1919.)
1916–1917	The Rt. Hon. Lord Cadman of Silverdale, G.C.M.G., Hon. LL.D., D.Sc., D.Eng., M.Inst.M.M. (died 1941.)
1917–1919	The Rt. Hon. Lord Greenway of Stanbridge Earls. (died 1934.)
1919–1921	Sir Frederick W. Black, K.C.B., B.A.(Lond.). (died 1930.)
1921–1923	Prof. John Samuel Strafford Brame, C.B.E., F.R.I.C.
1923–1925	Herbert Barringer, M.Inst.C.E., M.I.Mech.E., M.I.N.A., M.Inst.Mar.Eng. (died 1932).
1925–1927	Sir Thomas H. Holland, K.C.S.I., K.C.I.E., Hon. LL.D., D.Sc., F.R.S. (died 1947.)
1927–1929	Alfred C. Adams. (died 1948.)
1929–1931	A. E. Dunstan, D.Sc., F.R.I.C.
1931–1933	James Kewley, M.A., F.R.I.C., M.I.Chem.E. (died 1951.)
1933–1935	T. Dewhurst, A.R.C.S., F.G.S.
1935–1937	The Rt. Hon. Lord Cadman of Silverdale, G.C.M.G., Hon. LL.D., D.Sc., D.Eng., M.Inst.M.M. (died 1941.)
1937–1939	Lt.-Col. S. J. M. Auld, O.B.E., M.C., D.Sc.
1939–1942	Prof. A. W. Nash, M.Sc., M.I.Mech.E. (died 1942.)
1942–1944	C. Dalley, M.I.E.E. (died 1944.)
1944–1946	F. H. Garner, O.B.E., Ph.D., F.R.I.C.
1946–1948	Sir Andrew Agnew, C.B.E.
1948–1950	E. A. Evans, M.I.Mech.E., F.R.I.C.

COUNCIL

1951–52

President

C. A. P. Southwell, M.C., B.Sc.

Past-Presidents

Sir Andrew Agnew, C.B.E.
S. J. M. Auld, O.B.E., M.C., D.Sc.
J. S. S. Brame, C.B.E., F.R.I.C.
T. Dewhurst, A.R.C.S.
A. E. Dunstan, D.Sc., F.R.I.C.
E. A. Evans, M.I.Mech.E., F.R.I.C.
F. H. Garner, O.B.E., Ph.D., F.R.I.C.

Vice-Presidents

M. A. L. Banks, B.Sc., F.R.I.C.
E. J. Dunstan, M.Sc.
E. B. Evans, M.Sc., Ph.D., F.R.I.C.
F. Morton, Ph.D., F.R.I.C.
J. S. Parker, M.A., B.Sc.
H. C. Tett, B.Sc., D.I.C.

Members of Council

W. S. Ault, B.A.
V. Biske, LL.M., B.Sc., F.R.I.C.
C. D. Brewer, M.I.Mech.E.
F. L. Garton, M.A., B.Sc.
H. S. Gibson, C.B.E., M.A., M.I.Mech.E.
J. G. Hancock.
E. LeQ. Herbert, B.Sc., F.R.I.C.
H. Hyams.
J. A. Oriel, C.B.E., M.C., M.A.
H. E. F. Pracy, B.A.
D. L. Samuel, B.Sc., A.R.I.C.
G. H. Smith, Ph.D.
R. B. Southall.
E. J. Sturgess, B.Sc.
O. F. Thompson, O.B.E.
G. H. Thornley, M.Sc.
H. de Wilde, M.Sc., M.I.Mech.E.
A. T. Wilford, B.Sc., F.R.I.C.
C. S. Windebank, B.Sc., M.S.

Ex-Officio

I. McCallum, B.Sc. *Fawley Branch.*
N. E. F. Hitchcock, B.Sc. *London Branch.*
H. H. Ballard. *Northern Branch.*
W. M. Stirling, A.H-W.C., A.M.I.E.E. *Scottish Branch.*
E. J. Horley. *South Wales Branch.*
J. G. Cragg, B.Sc., F.R.I.C. *Stanlow Branch.*

Chairmen of Branches

Fawley Branch : G. Noble, B.Sc.
London Branch : A. J. Goodfellow, B.Sc., A.R.I.C.
Northern Branch : H. H. Ballard.
Scottish Branch : R. Crichton, J.P.
South Wales Branch : E. S. Squire, F.R.I.C.
Stanlow Branch : C. D. Brewer, M.I.Mech.E.
Trinidad Branch : J. L. Andrews.
Students' Section : Birmingham Branch : D. H. Hammerton, B.Sc.

LIST OF OFFICERS

Honorary Secretary
C. CHILVERS, B.Sc., F.R.I.C.

Honorary Treasurer
G. H. COXON.

Honorary Editor
F. H. GARNER, O.B.E., Ph.D., F.R.I.C.

Honorary Associate Editor
E. B. EVANS, M.Sc., Ph.D., R.F.I.C.

Editor
GEORGE SELL.

General Secretary
D. A. HOUGH, A.I.A.C.

Technical Secretary
PETER KERR, M.A., B.Sc., Hon. F.H-W.C., F.R.I.C.

Solicitors : Messrs. ASHURST, MORRIS, CRISP & Co.
Auditors : Messrs. GRAHAMS, RINTOUL, HAY, BILL & Co.
Bankers : WESTMINSTER BANK LIMITED, 115 Old Brompton Road, S.W.7.

Offices : Manson House, 26 Portland Place, London, W.1.

Telephone : LANgham { 2250. / 3682. }
MUSeum 2779.

Telegraphic Address : Instpetech, Westdo, London.

COMMITTEES OF COUNCIL

The President, Chairman of Council, and the Honorary Secretary are ex-officio Members of all Committees.

Aviation Products Data

F. L. GARTON (Chairman).
F. H. GARNER.
C. V. HILL.
K. C. HUNT.
F. MORTON.
A. R. STARK.

Awards Committee

H. S. GIBSON (Chairman).
G. H. COXON.
A. E. DUNSTAN.
E. A. EVANS.
F. H. GARNER.
H. C. TETT.

Benevolent Fund Committee

E. A. Evans (Chairman).
A. E. Dunstan
H. S. Gibson.
H. C. Tett.

Branches Committee

G. H. Thornley (Chairman).
H. Hyams.
F. Morton.
H. E. F. Pracy.
G. H. Smith.
R. B. Southall.

Birmingham University :
P. F. Jones

Fawley Branch :
I. McCallum.
G. Noble.

London Branch :
N. E. F. Hitchcock.
H. G. Spence.

Northern Branch :
G. M. Davies.
H. H. Ballard.

Scottish Branch :
R. Crichton.
W. Stirling.

S. Wales Branch :
E. J. Horley.
E. S. Squire.

Stanlow Branch :
V. Biske.
C. D. Brewer.

Trinidad Branch :
J. L. Andrews.
F. R. Buck.

Also representatives of overseas branches when available.

By-Laws Committee

V. Biske (Chairman).
W. S. Ault.
T. Dewhurst.
N. E. F. Hitchcock.
H. Hyams.
G. H. Thornley.

Education Committee

C. A. P. Southwell (Chairman).
W. S. Ault
E. B. Evans.
F. H. Garner.
F. Morton.
J. S. Parker.

Election Committee

E. J. Dunstan (Chairman).
W. S. Ault.
M. A. L. Banks.
C. D. Brewer.
N. E. F. Hitchcock.
H. E. F. Pracy.
G. H. Smith.
R. B. Southall.
G. H. Thornley.

Engineering Committee

E. J. Sturgess (Chairman).
R. E. Adlington.
G. C. Carr.
E. Evans-Jones.
A. McDougall.
A. D. Maclean.
F. Mayo.
J. S. Parker.
R. L. Sabjeant.
R. B. Southall.
H. de Wilde.

Finance Committee

H. Hyams (Chairman).
S. J. M. Auld.
M. A. L. Banks.
G. H. Coxon.
F. H. Garner.
F. Morton.
H. E. F. Pracy.
R. B. Southall.
H. C. Tett.
A. T. Wilford.

House Committee

S. J. M. Auld (Chairman).
M. A. L. Banks.
H. S. Gibson.
E. LeQ. Herbert.
H. Hyams.
H. de Wilde.

Publications Committee

F. H. Garner (Chairman).
V. Biske.
C. M. Cawley.
A. W. Deller.
E. B. Evans.
F. L. Garton.
C. L. Gilbert.
J. G. Hancock.
E. J. Horley.
H. Hyams.
F. Morton.
T. C. Owtram.
J. S. Parker.
J. Parrish.
H. E. F. Pracy.
D. L. Samuel.
E. Cooper Scott.
G. H. Smith.
W. H. Thomas.
A. Beeby Thompson.
P. M. de Veulle.
H. de Wilde.
C. S. Windebank.

Research Committee

F. Morton (Chairman).
S. J. M. Auld.
W. S. Ault.
J. W. Barrett.
B. W. Bradford.
E. J. Dunstan.
F. H. Garner.
H. S. Gibson.
R. Holroyd.
H. N. Short.
T. Tait.
C. S. Windebank.

Standardization Committee

F. L. Garton (Chairman).
S. C. Atkinson.
S. J. M. Auld.
D. I. Baddeley.
V. Biske.
W. E. J. Broom.
H. M. Davies.
G. W. Dorrell.
E. A. Evans.
E. B. Evans.
R. J. Forbes.
H. Gardner.
F. H. Garner.
P. J. Garner.
N. E. F. Hitchcock.
H. Hyams.
H. Jagger.
W. F. Jelfs.
C. D. Lawrence.
A. R. Lee.
J. Mason.
N. J. L. Megson.
A. Osborn.
J. S. Parker.
D. L. Samuel.
E. Stokoe.
T. Tait.
R. S. Teale.
F. B. Thole.
T. R. Thomas.
W. H. Thomas.
T. C. G. Thorpe.
J. D. F. West.
A. T. Wilford.
C. S. Windebank.

Honorary Members

R. P. Anderson.
T. A. Boyd.
E. W. Dean.
T. G. Delbridge.
J. G. Detwiler.
F. D. Tuemmler.

HON. SECRETARIES OF BRANCHES

Fawley Branch : I. McCallum, B.Sc., "Treside," New Road, Hythe, Southampton.

London Branch : H. G. Spence, B.Sc., c/o Shell Petroleum Co., St. Helen's Court, Gt. St. Helens's, London, E.C.3.

Northern Branch : G. M. Davies, c/o Esso Petroleum Co. Ltd., Mode Wheel Installation, Trafford Wharf Road, Manchester 17.

Scottish Branch : W. M. Stirling, A.H-W.C., A.M.I.E.E. Scottish, Oils Ltd., Middleton Hall, Uphall, Broxburn, W. Lothian.

South Wales Branch : E. J. Horley, National Oil Refineries Ltd., Llandarcy, Glam.

Stanlow Branch : V. Biske, B.Sc., LL.M., F.R.I.C., Lobitos Oilfields Ltd., The Refinery, Ellesmere Port, Cheshire.

Trinidad Branch : F. R. Buck, M.A., B.Sc., c/o Trinidad Leaseholds Ltd., Pointe-a-Pierre, Trinidad, B.W.I.

Students' Section : Birmingham Branch : H. A. T. Howe, B.Sc., c/o Dept. of Chemical Engineering, The University, Edgbaston, Birmingham 15.

CONTENTS

PAGE

Petroleum and European Recovery. Vernon Smith 2

A Method for Evaluating the Oxidation Stability of Inhibited Transformer Oils. G. H. Beaven, R. Irving, and C. N. Thompson 25

Dithionethiophanes. W. Friedmann 40

The Stability of Mineral Oils in Toilet and Cosmetic Preparations. W. W. Myddleton 46

Diffusion as a Rate-Limiting Factor in the Oxidation of Transformer Oils. R. Irving and C. N. Thompson 67

Alkylnaphthalenes. Pt VI, 1 : 3 Dimethylnaphthalene. R. F. Evans and J. C. Smith 80

Obituary : **G. W. Lepper** 91

A Symposium on Spectroscopic Methods in the Petroleum Industry

The Infra-red and Raman Frequencies of Hydrocarbon Groupings. N. Sheppard 95

The Absorption Spectra of Molecules in the Vacuum Ultra-violet. W. C. Price 106

Industrial Applications of Absorption Spectroscopy. Spectroscopic Panel of the Hydrocarbon Research Group 109

Some Criteria for Commercial Spectrometers. J. G. Reynolds 125

Acid Treatment of Shale Gasoline. Pt 1. Hydrolysis of Acids and of the Acid Sludge. R. C. Mathews and G. E. Mapstone 147

The Unit of Heat 158

A Symposium on the Institute of Petroleum Safety Codes

Model Code of Safe Practice in the Petroleum Industry. E. J. Sturgess . . 166

Application to Drilling and Production. H. de Wilde 181

Application to Refining. F. Mayo 186

Application to Marketing. R. L. Sarjeant. 192

Restraints on the Expansion of Vertical Tanks under Liquid Head. P. Kerr . 209

The Role of Peroxides in the Corrosion of Lead by Lubricating Oils. B. S. Wilson and F. H. Garner 225

Dehydrogenation of Tetrahydrothiophene. Walter Friedmann 239

Note on Dimethyl-dithienyl. Walter Friedmann 242

Investigation into the Olefinic Components of a Pennsylvanian Crude Oil. F. A. Haak and K. van Nes. 245

Notes on the Lubricating Effect of Colloidal Graphite. E. A. Smith 255

Studies in Shale Oil. Pt 1. Some Properties of the Gas Fraction. G. Nottes and G. E. Mapstone 259

Addition of Hydrogen Sulphide to *Iso*pentene with Aluminium Chloride as Catalyst. A. J. van Riemsdijk, J. Steenis, and H. I. Waterman 265

Correspondence : **Preparation of Specimens of Bitumen** 270

Obituaries : **Ernest Arthur Satchell** 271

James Kewley 273

Arthur Wade 273

Petroleum Waxes : Their Use and Evaluation for Paper Packaging. T. C. G. Thorpe 275

PAGE

Stability Test of Motor Lubricants. D. J. W. Kreulen 316

Annual Report 324

Thirty-eighth Annual General Meeting 337

Obituaries: **William Bruce Dick** 344

Reginald Aubrey Carder 344

A Symposium on Standardization

Crude Oil. H. Jagger 349

Gas, Diesel, and Fuel Oil. H. Gardner 352

Derived Chemicals. P. J. Garner 357

Greases. E. G. Ellis 358

Water in Transformer Oil. A Critical Résumé of the Causes and Effects of Water in Oil. M. R. Dickson 373

The Reaction of Dinitrogen Tri- and Tert-oxides with Olefins 2-Ethylbut-1-ene and Dec-1-ene. C. R. Porter and B. Wood 388

Substitution Products of the Isomeric Thiophthens. The Structure of Liquid Thiophthen (Thiopheno-2′ : 3′ : 3 Thiophen). F. Challenger and R. Emmott 396

Obituary: **Richard Paton Brownlee** 406

Third Cadman Memorial Lecture. Competitive and Co-operative Research in the American Petroleum Industry. Robert E. Wilson 407

Detergency of Carbon Black Suspensions. Pt III. In Toluene. F. H. Garner and A. R. W. Baddeley 426

Recent Developments in Test Methods for the Knock Rating of Aviation Gasoline. John Ogle 431

The Separation of Sulphur Compounds by Means of Mercuric Acetate. S. F. Birch and D. T. McAllan 443

Tests for the Consistency of Experimental Isobaric Vapour–liquid Equilibrium Data. E. F. G. Herington 457

Hydrodynamic Lubrication of Rotating Disks in Pure Sliding. A. Cameron . 471

A Symposium on Combustion Reactions in Relation to Gas Turbine Practice

Fuel for Aviation and Industrial Gas Turbines. M. O. Scott, R. Stansfield, and T. Tait 487

Some Considerations on the Combustion in Gas Turbines. J. G. Dawson . . 509

The Design of Combustion Chambers for the Coal-fired Gas Turbine. T. F. Hurley 517

An Experimental Study of the Evaporation and Combustion of Falling Droplets. J. E. C. Topps 535

The Flow Pattern of Gas Turbine Combustion. F. H. Garner and H. A. Cheetham 554

***n*-Heptane as a Standard Solvent for the Asphaltene Determination in Asphaltic Bitumen.** E. Eisma and C. J. Krom 583

Some Criteria for Commercial Spectrometers. Pt II. Comments by Manufacturers. J. G. Reynolds 588

Determination of Dry-sludge Content of Fuel Oils: Development of the Shell Hot Filtration Test (SHFT). W. J. Van Kerkvoort and A. J. J. Nieuwstad . 597

How to Train Refinery Engineers in Distillation. Ju Chin Chu 606

Geophysical Surveys on the Bahama Banks. C. S. Lee 633

The Jet Sampler—A Method of Obtaining Submarine Samples for Geological Purposes. K. W. Barr 658

PAGE

Obituary : **Eng. Comdr L. J. Le Mesurier, O.B.E.** 662

The Redwood Lecture. The Training of a Technologist. Professor F. H. Garner, O.B.E. 663

Performance and Accuracy of Amerada Bottom Hole Pressure Recorder. A. Laird and J. Birks 678

Brief History of the Search for Oil in the Australian Commonwealth. Arthur Wade 696

Our Unproduced Reserves : What Are They ? M. Muskat 717

Influence of Carbon Disulphide on Octane Number and Lead Susceptibility. G. E. Mapstone and J. S. Durham 737

The Expansion of Vertical Cylinders under Liquid Head. P. Kerr 740

Author Index 750

Name Index 753

Subject Index 757

ABSTRACTS

	PAGE
OILFIELD EXPLORATION AND EXPLOITATION	
Geology	562 A
Drilling	565 A
Oilfield Development	565 A
TRANSPORT AND STORAGE	566 A
REFINERY OPERATIONS	
Refineries and Auxiliary Refinery Plant	569 A
Distillation	571 A
Absorption and Adsorption	572 A
Solvent Extraction and Dewaxing	572 A
Cracking	573 A
Hydrogenation	574 A
Polymerization	575 A
Alkylation	575 A
Chemical and Physical Refining	575 A
Special Processes	576 A
Metering and Control	578 A
PRODUCTS	
Chemistry and Physics	578 A
Analysis and Testing	580 A
Crude Oil	581 A
Gas	582 A
Engine Fuels	582 A
Lubricants	583 A
Bitumen, Asphalt, and Tar	586 A
Special Hydrocarbon Products	587 A
Derived Chemical Products	588 A
Coal, Shale, and Peat	589 A
Miscellaneous Products	590 A
CORROSION	592 A
ENGINES AND AUTOMOTIVE EQUIPMENT	592 A
SAFETY PRECAUTIONS	593 A
MISCELLANEOUS	593 A
BOOK REVIEWS	594 A

AUTHOR INDEX

The numbers refer to Abstract Numbers

Adelson, D. E., 2727
Alden, R. C., 2758
Allen, J. G., 2684
Altpeter, J., 2727
Ando, H., 2723
Angell, R. F., 2756
Arabian, K. G., 2749
Arnold, M. L., 2643–4
Ashmore, S. A., 2707

Baker, D. R., 2667
Banta, H. M., 2653
Barkow, A. G., 2647
Barnhart, P. S., 2749
Barr, F. T., 2718
Bartleson, J. D., 2727
Bartlett, J. H., 2727
Barton, R. C., 2727
Baxter, A., 2641
Bearse, A. E., 2698
Bellam, D. J., 2695
Benson, T. S., 2690
Bergstrom, R. F., 2727
Bickel, W. D., 2740
Bieler, W., 2710
Bishop, R. B., 2737
Blade, O. C., 2719
Bok, H., 2722
Bondy, H. F., 2741
Bowles, V. O., 2685
Brancker, A. V., 2700
Brandon, R. C., 2685, 2690
Brooks, M., 2666
Brooks, J. W., 2727
Buchan, R. C., 2624
Buchmann, F. J., 2694
Buls, M., 2737
Burgard, A., 2694
Busche, R. M., 2705
Butenuth, G., 2674

Cambron, A., 2737
Campise, N. O., 2624
Cantrell, T. L., 2721
Chapman, F., 2735
Chu, J. C., 2705
Clark, K. A., 2728
Clarke, E. W., 2690
Connor, J. P., 2681
Cornell, P. W., 2690
Coupard, C. J. C. D. F., 2727
Crowell, J. H., 2691
Cyphers, E. B., 2727

Danckwerts, P. V., 2675
Dannenberg, E. M., 2742
Denton, W. I., 2737
Derksen, J. C., 2732
Dietz, R. S., 2613
Dinneen, G. U., 2740
Donath, E., 2694
Duff, D. M., 2625
Duncan, G. W., 2753

Edelstein, S. M., 2746
Egloff, G., 2757
Eichelmann, J. F., 2642
Ekholm, E. L., 2694
Emmett, P. H., 2762

Fairbairn, A. W., 2737
Feldman, J., 2673
Fetterly, L. C., 2690
Fiedler, H. P., 2727
Florin, F., 2669
Foster, A. L., 2682
Fowler, F. C., 2670
Franck, H., 2732
Franklin, L. U., 2689
Free, G., 2685, 2716
Friedman, S., 2692–3
Fuchs, W., 2738
Fulton, R. A., 2744

Gardner, J. B., 2690
Gartner, A. I., 2663
Gee, K. W., 2674
Gianoli, E., 2712
Gilbert, W. I., 2690
Girelli, A., 2713
Gishler, P. E., 2665
Gislon, A., 2694
Goldsmith, L. M., 2761
Grace, E. J., 2696
Green, F. R. G., 2690
Gresham, W. F., 2737

Hadley, D. J., 2737
Haendel, H., 2694
Halbouty, M. T., 2621
Hall, A. M., 2653
Hammond, R., 2646
Hangs, F. G., 2638
Hanmer, R. S., 2689
Hannum, J. A., 2749
Hardin, G. C., Jr., 2621
Harman, D., 2727
Harrison, J. M., 2674
Hawkins, E. G. R., 2737
Heap, R., 2737
Heimberger, W., 2718
Hemminger, C. B., 2694
Henaill, G. S., 2743
Hepp, H. J., 2685
Herbert, W., 2694
Hicks, T. G., 2661
Hilfiger, J. P., 2711
Hill, A. G., 2679
Hoiberg, A. J., 2733
Hopkins, R. L., 2677
Hoppe, P., 2721
Horne, D., 2741
Horne, W. A., 2690
Hughes, E. C., 2688, 2737
Hume, G. S., 2717
Hurter, H., 2731

Ilveskorpi, M., 2732
Ingalls, P. C., 2618–19, 2622
Ivey, F. E., Jr., 2709

Jansen, H. A., 2755
Jennings, A. S., 2705
Jewell, J. W., 2681
Johnson, G. C., 2737
Johnson, S. P., 2631
Johnstone, H. F., 2699
Jones, W. O., 2678
Jordan, G. F., 2616

Kaplan, W., 2695
Kendall, B. J., 2697
Kilpatrick, M. C., 2685
King, L. F., 2737
Kipp, E. M., 2737
Klein, H., 2694
Knaggs, E. A., 2702
Kohrt, H. U., 2674
Komarevsky, V. I., 2702
Kraemer, A. J., 2739
Kranepuhl, E., 2737
Kraus, P., 2685
Krebs, R. W., 2694
Kremer, L., 2748
Kronstein, M., 2732
Kuwata, T., 2723

Lacey, W. N., 2704
Lange, G., 2737
Larson, C. M., 2734–5
Larson, E. R., 2617
Lassiat, R. C., 2685

Leason, D. B., 2720
Ledoyen, L. A., 2685
Leger, F. M., 2727
LeRoy, R. M., 2690
Lesser, M. A., 2745
Leva, M., 2691
Lieber, E., 2727
Linsenmeyer, J. C., 2660
Little, D. M., 2684
Lovell, S. P., 2749
Lowe, A. J., 2735

McAdams, U. R., 2694
McKim, F. L. W., 2737
McNeil, D., 2686
Mahan, J. R., 2721
Maltby, L. K., 2708
Manley, H. B., 2635
Marshalle, R. P., 2741
Marx, O., 2741
Massiot, L., 2674
Matheson, G. L., 2685
Medcalf, E. C., 2679
Menard, H. W., 2613
Meyer, K., 2731
Mikeska, L. A., 2727
Miller, J. C., 2749
Miller, R. J., 2701
Minnaar, H. W. T., 2730
Moehrle, E., 2741
Monicard, R., 2715
Morin, R. D., 2698
Morley, R. H. H., 2727
Morris, L. C., 2687
Mueller, N. F., 2705
Müller, H., 2718
Munday, C. W. A., 2727
Munday, J. C., 2727
Myles, M., 2673

Neppe, S. L., 2729
Nettlenbusch, L., 2690
Nichol, R. J., 2737
Noguchi, S., 2723
Norman, N. E., 2699

O'Halloran, R., 2727
op ten Noort, L. H., 2652
Orchin, M., 2675
Oschats, F., 2694
Othmer, D. F., 2671

Parker, M. E., 2750
Pasternack, D. S., 2728
Pattison, J. N., 2703
Paxton, C. E., 2753
Peavy, C. C., 2685
Peel, D. H., 2694
Pelipets, M. G., 2692–3
Perry, G. L., 2727
Peterson, W. S., 2668
Pierotti, G. J., 2737
Plantfeber, J. M., 2727
Poster, F. W. B., 2690

Quiquerez, J., 2694

Raimondo, E., 2712
Rappen, L., 2741
Reamer, M. H., 2704
Reamer, T. E., 2753
Redmond, W. P., 2639
Reeves, E. D., 2721
Reider, C. M., 2737
Reilly, P. M., 2672
Reitz, O., 2694
Rich, J. L., 2614
Richter, F. P., 2727
Ridlington, J., 2654
Roach, D. A., 2633
Robinson, S. P., 2734
Rockwell, R. A., 2662
Roegiers, M., 2706
Rogers, D. T., 2727

Sachanen, A. N., 2727
Sage, B. H., 2697, 2704
Savage, R. T., 2685
Savoy, M., 2678
Schertel, L., 2685
Schiller, J. C., 2694
Schlesinger, M. D., 2691
Schmerling, L., 2734
Schnur, F., 2686
Schuftan, P. M., 2690
Schulze, W. A., 2721
Schutte, A. H., 2685
Schwarz, F., 2690
Seebohm, H. B., 2674
Seltzer, K. P., 2742
Sexauer, W., 2690
Shand, E. W., 2685
Shanley, W. B., 2687
Shmidl, A. J., 2734
Shoemaker, B. H., 2727
Simon, W., 2685, 2694
Siniramed, C., 2712–13
Sloss, L. L., 2612
Smith, H. G., 2721
Souders, M., 2734
Spicer, W. B., 2694
Sproule, L. W., 2727
Stevens, D. G., 2688
Stiebling, E., 2686
Storch, H. H., 2691
Storey, J. B., 2749
Stormont, D. H., 2640, 2754
Strachan, M. N., 2749
Sugimoto, R., 2721
Sumerford, S. D., 2694
Swaminathan, V. S., 2658, 2759–60
Sweetser, S. B., 2694

Talley, S. K., 2727
Tanaka, T., 2676
Taylor, F., Jr., 2714
Ten Eyck, E. H., 2671
Thorne, H. M., 2739
Thornton, D. P., 2656
Thorp, A. B., 2654
Thorpe, R. E., 2727
Timothy, P. H., 2645
Tolin, S., 2671
Tompkins, L. G. R., 2690
Trusler, R. B., 2747

van Loon, W., 2718
Veatch, F., 2685
Vickery, D. S., 2707
von Bethmann, M. F., 2686
von Flinor, W., 2685
Vriens, G. N., 2679

Waddill, P. M., 2684
Wagner, C. R., 2737
Weller, S., 2692–3
Wender, J., 2673
Wille, H., 2741
Winkler, F., 2721, 2741
Wolff, W., 2694
Wolosewick, F. R., 2664

Yoshida, F., 2676
Young, J. E., Jr., 2752

Zechetmayr, O., 2694
Zimmer, J. C., 2753

Oilfield Exploration and Exploitation

Geology

2612. Stratigraphical analysis in oil exploration. L. L. Sloss. *Oil Gas J.*, 13.9.51, **50** (19), 102.—The use of facies maps in interpreting regional stratigraphy in sedimentary areas is described. In compiling such maps the selection of the parameters to be plotted depends on the nature of the problem and the result required.

A hypothetical example of applied stratigraphical analysis is given, and it is shown how, from a series of facies maps, favourable prospecting areas may be sought.

Examples of isopach–lithofacies maps of the Mississippian system in the Rocky Mountain area and in Montana are included. C. A. F.

2613. Origin of abrupt change in slope at continental shelf margin. R. S. Dietz and H. W. Menard. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35** (9), 1994–2016.—The margins of the continents lie beneath the sea. The submarine part of a continent is called the continental terrace, and is divided into two parts, the continental shelf and the continental slope. A typical continental shelf is a smooth plain with a seaward slope of 10 ft/mile (0·1°). Shelves range in width from a few miles to several hundred miles; the average width is 40 miles. A typical continental slope has very irregular topography, and an average slope of about 500 ft/mile (5°). The change in slope from the gentle continental shelf to the steep continental slope is very abrupt. The authors of this paper believe that the origin of the abrupt change in slope provides the key to the recent geological history of the continental terrace.

An abrupt change in slope marks the boundary between the continental shelf and the continental slope. The slope change previously has been attributed to: (1) sedimentation at wave base and in equilibrium with present sea-level; (2) sedimentation at wave base but related to some past lowered sea-level; (3) wave abrasion in equilibrium with present sea-level; and (4) wave abrasion related to some past lowered sea-level. To test these various possible origins, the concept of "wave base" is examined theoretically. It is found that wave base appears unimportant in the

regimen of the sea, and it does not account for the observed "shelf-break." The break appears to be related to the depth at which breakers form which, excluding rare cases, is at a max of about 5 fathoms. The writers term this the "depth of vigorous abrasion." On theoretical grounds it appears, therefore, that the break-of-slope is caused by wave abrasion related to a sea-level lowered to within about 5 fathoms of the break. This theory is tested with several field facts, and these appear to confirm it. For example, the depth of the shelf-break is approx the same on the windward and the leeward side of island which is in agreement with the concept of the break being formed at the depth of vigorous abrasion, but is in disagreement with the concept of wave base.

Some geological implications of this theory are briefly discussed. These are: (1) sea-level has recently (geologically speaking) risen eustatically, (2) this recent rise has taken place more rapidly than changes of land-level effected by erosion, sedimentation, or diastrophism. E. N. T.

2614. Probable fondo origin of Marcellus–Ohio–New Albany–Chattanooga bituminous shales. J. L. Rich. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35** (9), 2017–40.—Bituminous shales are products of exceptional depositional conditions which give them extraordinary value as stratigraphic and sedimentational markers in addition to their scientific interest as possible source beds for oil, and their economic value as potential oil reserves.

This paper is intended as a contribution to the problem of the environmental conditions which lead to the formation of bituminous shales as they are exemplified by that widespread and presumably continuously connected body of black, bituminous shale called locally, or in its various westward-converging units, the Marcellus, Genesee, Middlesex, Rhinestreet, Burket, Harrell, Ohio, Huron, Antrim, Sunbury, New Albany, and Chattanooga.

The problem of the depositional environment of the bituminous shales is attacked by means of an analysis of the evidence for and against a fondo (relatively deep-water) origin of a specific body of black, bituminous shale in North America.

Attention is called to many features which indicate deposition in relatively deep, quiet, toxic water, as well as to others definitely opposed to a current concept that the shales were formed in very shallow water near shore by re-working of residual soils on a peneplain by the waves of a transgressing sea.

Among the features indicating a fondo environment are: the very nature of the material, with its large content of light-weight organic material which would not ordinarily come permanently to rest in any but quiet water; widespread beds of phosphate nodules; phosphatic material and a lag concentrate of miscellaneous marine débris such as conodonts, fish plates, etc., in the lower few inches of the shales; very thin, evenly stratified beds of siliceous and partly calcareous material, probably representing falls of volcanic ash, that are too evenly bedded and too widespread to have been subjected to wave action or to other disturbing influences; and faunal features indicating pelagic rather than near-shore conditions. One of the most important features strongly opposed to a shallow-water near-shore environment is the lack of evidence of wave action, such as should exist and should be unmistakable if the materials had been deposited in shallow water near shore. Further, the contact of the bituminous shales with the underlying rock fails to show important features which should have been produced if a sea had advanced over a peneplaned land surface. E. N. T.

2615. Another oiler indicated. Anon. *Oil Gas J.*, 13.9.51, **50** (19), 80.—1 Harry Bakken in the Williston Basin, North Dakota, flowed oil from 8304 to 8360 ft from a zone believed to be Mississippian–Madison.

Pay has now been found in three formations in the Williston Basin; Devonian, and Mississippian Charles? and Madison. C. A. F.

2616. Continental slope off Apalachicola River, Florida. G. F. Jordan. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35** (9), 1978–93.—The progress of hydrographic surveys on the continental slope in the Gulf of Mexico was interrupted in 1941 by the exigencies of the second world war. In the preceding decade, surveys completed off the coasts of Texas and Louisiana had revealed many interesting features.

In 1947 the United States Coast and Geodetic Survey resumed offshore surveying operations on the continental slope southwest of the Apalachicola River, Florida. Two significant factors contribute to the value of the new surveys—the development of the electronic position indicator for use in positioning the survey ship accurately far out on the slope and Gulf floor and the development of the electronic depth recorder, which provides a continuous graphic profile of the submarine topography.

In this paper, which summarizes the latest results, illustrations are presented which reveal the physiography of a large part of the continental slope in an area not previously covered by hydrographic surveys. Graphic profiles obtained from electronic depth recorders reveal marine domes and details of the continental escarpment and shelf margin. No conclusions are presented, as interpretation of the submarine topography is left to the geologist. E. N. T.

2617. Stratigraphy of Plattin group, south eastern Missouri. E. R. Larson. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35** (9), 2041–75.—Re-study of the Middle Ordovician Plattin formation of southeast Missouri to determine the mode of its northward thinning has led to the establishment of the Plattin group of four formations, which are defined.

Northward thinning of the Plattin group, from approx 400 ft at Cape Girardeau to approx 125 ft in southern Lincoln County is by convergence within units and offlap and overlap of units. The Beckett formation overlaps the oolite-bearing Bloomsdale. The Hager formation disconformably offlaps the Beckett. The Macy formation thins by the reduction of the fucoidal part; the upper member is essentially plate-like.

The Plattin has been classified as Bolarian, Black River in age, and correlated with the Platteville of the upper Mississippi valley. Faunules from the upper Macy suggest that those beds are lower Trentonian. Lower formations resemble the Bolarian in central Kentucky and central Pennsylvania. E. N. T.

2618. Devonian discoveries in Lea County. P. C. Ingalls. *Oil Gas J.*, 30.8.51, **50** (17), 115.—Two wells in Lea County, New Mexico, have recently found production in the Devonian; 1-EC A State flowed 186 brl of 42° oil in 4 hr from 11,250 to 11,270 ft, and 1-AR State flowed 38 brl of 41° oil in 4 hr from 11,500 to 11,580 ft.

Little is known of the Devonian rocks in this area; in the Denton field 800 ft of oil-saturated dolomite has been found, but the productive limits are unknown.

To the west Devonian is found at shallow depths, and there is production at Lightcap, Chisum, and Twin Lakes. C. A. F.

2619. Oklahoma's Springer sands. P. C. Ingalls. *Oil Gas J.*, 6.9.51, **50** (18), 137.—Springer production was first found seven years ago on the northeast flank of the Velma field, and subsequent exploration and development has been mainly in the Ardmore Basin and in the Velma–Sholem Alechem–Fox area. In the future there may be development of Springer production in the Anadarko Basin in the north and west.

The southern limit of the Springer sands is just north of the Wichita Mountain front; the limit to the north is unknown, except at the southeastern edge of the basin, but the formation thins northward from the basin axis.

Structures in the area are complex, and there is much faulting. C. A. F.

2620. Goose Creek again active. Anon. *Oil Gas J.*, 30.8.51, **50** (17), 48.—A deep pay has been discovered in the Goose Creek field, Harris County, Texas. 1 Otis E. Donahoe flowed 1000 b.d. from 4616 to 4620 ft. Additional wells are planned. C. A. F.

2621. Types of hydrocarbon accumulation and geology of South Liberty salt dome, Liberty County, Texas. M. T. Halbouty and G. C. Hardin, Jr. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35** (9), 1939–77.—Gulf Coast Tertiary strata constitute one of the most prolific producing oil provinces in the world, yet there is little regional folding and an absence of large tectonic movements, and therefore no major structural features of great relief which characterize many other oil-producing provinces. The Gulf Coast was, and still is, an area of low relief, both inside and beyond the coast-line, with deposits through the Tertiary made up principally of continental beds and of sedi-

ments deposited in shallow marine waters, with a series of regressions and transgressions, with the net effect of moving the shore-line towards the south. During these oscillations there occurred erosional periods and consequent minor, but effective truncation of beds and traps for accumulation of oil and gas. Despite the absence of structures of great relief, accumulations of hydrocarbons are present in the Gulf Coast with less intense features of every known type: anticlines, faults, faulted anticlines, sand lenses, stratigraphic traps of all types, reefs, and a combination of these structural and stratigraphic forms.

The various types of hydrocarbon accumulations have been proved by drilling on the Gulf Coast salt domes, and one of these, the South Liberty salt dome in Texas, 45 miles east of Houston, is chosen as the subject of this paper, because it exemplifies the economic importance of various types of oil traps which were formed at several stages in the growth of the dome. E. N. T.

2622. Reef developments south of Leduc. P. C. Ingalls. *Oil Gas J.*, 13.9.51, **50** (19), 157.—D_2 production has recently been found 30 miles south of Big Valley in 30–14 Drumheller, which flowed over 1000 b.d. of 30° oil from 30 ft of D_2 above 5400 ft. Excepting a well at Princess, 70 miles to the southeast, this is the most southerly D_2 well.

A well, 1 Olds, between Stettler and Turner Valley, flowed 50 to 70 M.M.c.f. gas and 700 b.d. condensate from 8100 to 8112 ft from the D_3. This is the deepest reef discovery in Alberta.

A number of other wells south of Leduc have found pay in the Devonian D_2 and D_3. C. A. F.

2623. New gas strike reported. Anon. *Oil Gas J.*, 30.8.51, **50** (17), 53.—1 Brock in west-central Saskatchewan flowed gas estimated at 5,000,000 to 8,000,000 cu.ft/day from 2357 to 2380 ft. The well is 25 miles from 1 Smiley, the second gas strike in Saskatchewan. C. A. F.

Drilling

2624. Patents. The following U.S. patents, assigned to Phillips Petroleum Co., relate to drilling muds designed to reduce fluid loss through the filter-cake formed on the wall of the well, containing in :—

2,561,418 (18.8.47; 24.7.51). Water-soluble salts of substituted starch acids and/or inulin acids and/or water-soluble substituted starch ethers and inulin ethers;

2,560,611 (15.3.48; 17.7.51). Water-soluble cellulose acid sulphate or its metal or ammonium salts;

2,560,612 (10.12.45; 17.7.51). Water-soluble cellulose sulphate and/or phosphate.

U.S.P. 2,560,930 (23.8.48; 17.7.51). N. O. Campise, assr to Houston Oil Field Material Co. Inc. Drilling fluid containing equimol amounts of alkali-metal carbonate and alkaline-earth hydroxide, and a tannin.

U.S.P. 2,560,331 (30.7.48; 10.7.51). H. C. Buchan, assr to Standard Oil Development Co. Iron pipes carrying corrosive fluids encountered in well drilling are protected by treatment with alkali-metal silicate solutions. V. P. P.

Oilfield Development

2625. Production record set. D. M. Duff. *Oil Gas J.*, 30.8.51, **50** (17), 56.—World production in June 1951 was approx 12,016,000 b.d., approx 24,000 b.d. higher than the previous month, in spite of a drop of 80,000 b.d. in Iranian production. This drop was offset mainly by increased production in the U.S.A., Kuwait, and Saudi Arabia.

U.S.A. production in June was estimated at 6,182,000 b.d.

A table gives crude production by countries for May and June 1951 and June 1950. C. A. F.

TRANSPORT AND STORAGE

2626. The Scottish pipeline. Anon. *Petroleum*, Apr. 1951, **14** (4), 91–3.—Describes the plan, route, and some of the problems connected with the construction of the Scottish pipeline designed to carry Middle East crude oil from the port of Finnart, Dumbartonshire, to the refinery of the Anglo-Iranian Oil Co., at Grangemouth in Stirlingshire. R. E. P.

2627. Middle Eastern pipelines. Anon. *Petroleum*, Apr. 1951, **14** (4), 94–6.—Discusses the importance of trans-desert pipelines projected and constructed in the Middle East. R. E. P.

2628. Constructing the Richfield line from Cuyama Valley. Anon. *Pipe Line News*, 1951, **23** (8), 22–30.—Details are given of two new sections, 58-mile and 54-mile respectively, added to Richfield's existing system, to handle light crude oil from the Russell Ranch field, with a pictorial account of the terrain covered, details of a suspension bridge crossing the Alamos Creek, and of pumping stations powered by diesel engines using the crude oil as fuel. F. M.

2629. Texas–Illinois 1400 mile gas line. Anon. *Pipe Line News*, 1951, **23** (9), 25–30.—An account of progress to date in the laying of the 1400-mile pipeline from Wharton, Texas, to Chicago which is scheduled for completion in December. Storage of 90 billion cu. ft. of gas in a stratum of highly porous and permeable Galesville sandstone which underlies Herscher at a depth of 1600 ft is proposed. F. M.

2630. Design and construction of the Mid-Valley system. Anon. *Pipe Line News*, 1951, **23** (5), 22–38.—Details are given of the design, construction, and laying of the Mid-Valley 22-inch pipeline for the transportation of 157,000 b.d. of crude oil from Longview, Texas, to Lima, Ohio. Basic line-design features, pumping-station facilities, manifold and tank-line details are included with a brief description of the "Limitorque" operated controls at the pumping-station. Diagrams illustrate the layout of piping, control valves, diesel-engine arrangements, etc., of one of the main stations (Abbeville). The Mississippi crossing at Mayersville is also reviewed. Design capacities for the various sections and for the spur lines are included. F. M.

2631. Salt Lake Pipe Line Co. system. S. P. Johnson. *Pipe Line News*, 1951, **23** (6), 29–36.—Unusual features of the Salt Lake Pipe Line Co's 566-mile, 8-inch pipeline from Salt Lake City to Pasco, Washington, are given. The line handles two grades of gasoline, two or more grades of stove oil, and substantial quantities of diesel oil. Only two pumping-stations are used, although two more are being designed. Details are given of pipeline construction, pumping-station design and layout, and of the use of radioactive tracers for indicating the position of the interface between two products in the lines. F. M.

2632. Survey of natural gas pipelines. Anon. *Pipe Line News*, 1951, **23** (6), 22–3.—An abstract of the annual review of the Gas Appliance Manufacturers Assn giving details of mileage of gas pipelines laid in 1950 and projected in 1951 with capital expenditure and cities served. F. M.

2633. Pipeline transportation, storage and shipment of LPG gas. D. A. Roach. *Pipe Line News*, 1951, **23** (9), 31–4.—An account of the pipeline transportation of liquefied propane and butane with details of storage tankage, product buffer slugs, and pumping installations. F. M.

2634. Pipeline equipment progress. Anon. *Petroleum*, Apr. 1951, **14** (4), 104–9.—A review of some of the more important recent developments in British equipment for pipeline laying and maintenance. R. E. P.

2635. Economic line sizing for plant piping. H. B. Manley. *Refiner*, 1951, **30** (7), 151–52.—A nomogram for the selection of economic allowable pressure drops through lines is given. Costs of pumping and various types of operating conditions are taken into account. Figures are based on \$30/h.p/year and current equipment costs. R. W. G.

2636. Pipelines given fast amortization. Anon. *Pipe Line News*, 1951, **23** (6), 23.—Brief details of the report of the Senate Banking and Currency Committee recommending that pipeline construction be given an incentive in the form of speedy tax write-off privileges of part of the cost. The Petroleum Administrator for Defence is studying the overall transportation problem, and as yet has not certified any pipeline construction as necessary. Details of the amortization rates anticipated are given. F. M.

2637. Making steel pipe. Anon. *Petroleum*, Apr. 1951, **14** (4), 98–100.—A description of the manufacture and testing of steel pipe at the Clydesdale works of Stewarts and Lloyds Ltd. R. E. P.

2638. Three helpful charts for pipe liners. F. G. Hangs. *Oil Gas J.*, 4.10.51, **50** (22), 255.—Charts show determinations of working stress in pipeline, estimation of length of pipeline occupied by given volume of crude oil or products, and estimation of height occupied by given vol of liquid in tanks of different dia. G. A. C.

2639. Friction losses in large-diameter crude-oil pipelines. W. P. Redmond. *Oil Gas J.*, 4.10.51, **50** (22), 306.—Friction factor tests on 24- and 26-inch pipelines have been made by Creole Petroleum Corp., and factors are found to be in good agreement with those derived by Stanton and Pannell in 1914. The results of tests on the lines are tabulated, and a modified D'Arcy equation given. G. A. C.

2640. How to make viscous liquids flow. D. H. Stormont. *Oil Gas J.*, 4.10.51, **50** (22), 224.—Heating a viscous crude oil and blending with gas oil by General Petroleum Corp. at San Ando, Calif., to enable easier pumping, are described. Two intermediate stations for re-heating and boosting the pressure are required on the 42-mile system between field and coast terminal. G. A. C.

2641. Products pipeline scraping operations. A. Baxter. *Pipe Line News*, 1951, **23** (8), 31–4.—The experiences of the Keystone Pipe Line Co. with scrapers are outlined with data on scraper operations, types of scrapers, corrosion inhibitors, and scraper-trap design. F. M.

2642. Features of a gas turbine centrifugal pipeline compressor station. J. F. Eichelmann. *Pipe Line News*, 1951, **23** (6), 24–8.—Details are given of gas-turbine-driven centrifugal compressor stations for natural-gas pipelines designed by G.E.C. for the El Paso Natural Gas Co. Advantages of the gas turbine, cost data, operating schedules, pumping-station layout, and compressor design are discussed and illustrated. F. M.

2643. Pulsation dampers in compressor piping systems. M. L. Arnold. *Oil Gas J.*, 11.10.51, **50** (23), 109.—Experiences and causes of pulsative flow, resulting in fatigue failure of piping and heat-exchanger tubing, and increased costs of pumping gas, are discussed, together with remedial measures.

Gas from a compressor cylinder emerges as " puffs," which result in a pressure wave which may travel back along the pipe in a direction opposite to gas flow. It is proposed to instal two volume chambers to suppress effects of pulsative flow, and flow sheets are given for piping arrangement and test-header layout. Pulsation dampeners were applied for purpose of improving gas measurement.

The work of Murphy on pulsations is also discussed, and it is concluded that orifice plates and piping resistance have little effect on natural frequency of a system, whilst surge chambers have a very pronounced effect in lowering the natural frequency. G. A. C.

2644. Experiences in dampening pulsations in compressor piping system. M. L. Arnold. *Pipe Line News*, 1951, **23** (9), 35–40.—A discussion of the causes of pulsative flow in compressor-station piping, with an account of results obtained using acoustical filters. F. M.

2645. Breaks in pipeline river crossings. P. H. Timothy. *Oil Gas J.*, 4.10.51, **50** (22), 243.—From a study of a series of breaks in pipeline crossings of the Mississippi River the probable causes of failures and remedial measures have been indicated.

Causes of breaks include scour of banks, hydrodynamic forces, caving banks, and rise of concrete mats.

Successful crossings will depend on study of probable changes in velocity of stream, and designs should be flexible. G. A. C.

2646. Welded oil pipelines. R. Hammond. *Petroleum*, Apr. 1951, **14** (4), 87–90.—Reviews the development, techniques, and progress in the welding of oil pipelines. R. E. P.

2647. How to interpret radiographs of pipeline welding defects. A. G. Barkow. *Oil Gas J.*, 4.10.51, **50** (22), 177.—The more common defects in pipe welds, found by radiographic inspection and by actual examination of a cross-section of the specimen are described and illustrated.

Among defects discussed are undercutting, arc tracks, surface cracks, narrow and offset cover bead, slag and wagon cracks, lack of root penetration, bead and fusion and burn-through. Experience is necessary to correctly interpret the radiographs; this is gained by study and a basic knowledge of natural shape and principle location of various weld defects. G. A. C.

2648. Pipe weld examination. Anon. *Petroleum*, Apr. 1951, **14** (4), 97.—Briefly describes the modern non-destructive technique of weld examination with X-rays from special equipment, and with gamma-rays emanating from radioactive isotopes. R. E. P.

2649. Remote-reading gauges improve Portland's tank-farm operation. Anon. *Oil Gas J.*, 4.10.51, **50** (22), 190.—Automatic tank gauges have been installed on floating-roof tanks in crude oil service at the tank farm at South Portland belonging to Portland Pipe Line Co.

The instruments operated successfully even in severe winter weather; among advantages are increases in throughput made possible without increasing work load, direct labour costs reduced, more accurate gauging, and elimination of large amount of personnel discomfort and risk.

Hourly trunk-line checks are easily made, and daily stock checks greatly facilitated. An operating chart compares manual *v* automatic systems. G. A. C.

2650. Design and manufacture of pressure vessels. Anon. *Petroleum*, May 1951, **14** (5), 127–30. (Extracted from *Proc. Third Conf. on Chemical Works Safety.*)—Summarizes the different points of view put forward by a manufacturer, who is mainly interested in efficient design and fabrication, and a user, who desires cheap pressure vessels which will operate without danger to personnel or plant. These different viewpoints were discussed in two papers dealing with fusion-welded pressure vessels in reference to British Standard Code, 1500. R. E. P.

2651. New plant for testing pressure vessels. Anon. *Petroleum*, June 1951, **14** (6), 159.—Describes a pulsating pressure plant installed in the pressure-vessel laboratory of the British Welding Research Association at Abington, Cambridge, for testing vessels and other products by repeated applications of pressure.

Advantages of this type of test over normal static pressure tests are: (1) vessels which will be subjected to varying pressures in service, can be tested under similar conditions during their initial development so that a relation between material properties, service stress, and life expectation can be established; (2) it will distinguish between two designs of otherwise equal merit far more readily than will a static test.

Connexion of the pump to the test vessel is alternately made and severed by a valve controlled by a pneumatic–hydraulic arrangement. The main pump, by which the test vessel is subjected to pressure, is a three-ram pump capable of a delivery of 12 g.p.m. against a pressure of 6000 p.s.i. driven by a 75-h.p. electric motor. It is possible to vary the shape of the loading cycle and also to alter the limits of the test while this is proceeding. Pressure limits at present are between 0 and 6000 p.s.i., and it is possible to obtain 100 c.p.m. R. E. P.

2652. Prestressed concrete tanks. L. H. op ten Noort. *Ingenieur*, 7.9.51, **63** (36), Bt. 65.—Describes the design and calculation of 375,000-gal prestressed concrete tanks. The use of high-strength wire makes possible considerable economies in steel and con-

crete. The tanks are completely watertight, and the permanent protection of the reinforcement against corrosion is fully provided for. Details of the constructional procedure are given, and a number of photographs are included to illustrate the article. R. R.

2653. Graphitization of steel. A. M. Hall and H. M. Banta. *Oil Gas J.*, 11.10.51, **50** (25), 101.—Steel consists of a thermodynamically unstable mixture, which under prolonged exposure at elevated temperatures will decompose with formation of graphite carbon, resulting in a thermodynamically stable mixture of iron (ferrite) and graphite. When the graphite is formed in local and high concentrations, mechanical failure will ensue. Most frequently occurring is localized graphitization near welded joints. The process is strongly influenced by temp. Various types of steel display differences in inherent susceptibility to graphitization, for example, steels containing more than 0·5% chromium are highly resistant to graphitization, whilst carbon and carbon–molybdenum steels are susceptible.

Graphitization can be detected only by examination under the microscope of samples taken from equipment concerned; there is no non-destructive testing procedure yet available. G. A. C.

2654. Patents. B.P. 653,670 (8.7.48; 23.5.51). A. B. Thorp and Steel Barrel Co. Ltd. Filter devices are arranged in the interior of a hose reel for refuelling tankers, and are connected to the source of fuel supply and to the hose wound on the reel so as to filter the liquid before passing into the hose.

B.P. 654,520 (22.6.48; 20.6.51). J. Ridlington and J. R. Engineering Co. Ltd. Locked filter-cap for petrol tanks. V. P. P.

Refinery Operations

Refineries and Auxiliary Refinery Plant

2655. Refinery is advanced example of combination oil processing. Anon. *Refiner*, 1951, **30** (7), 146.—A brief description of the British-American Co. 5200-brl combination processing plant opened in June near Edmonton, Alberta. Facilities include crude topping, delayed coking, catalytic and thermal cracking, gas recovery, and treating for white products. R. W. G.

2656. New crude topper, cracker expand independent refiner's facilities. D. P. Thornton. *Petrol. Process.*, 1950, **5** (11), 1176–9.—The extensive re-organization and expansion programme under way at the Cushing, Okla., refinery of Deep Rock Oil Corp. is described. A new 4750-b.s.d. crude topping unit brings the total crude capacity to 14,000 b.d. The reduced crude from the topping units is vis-broken to feed stock for a new 4975-b.s.d. U.O.P. "package design" fluid catalytic-cracking unit. The vis-breaker is a converted thermal cracking unit which had separate vis-breaking and cracking heaters. Several unusual auxiliaries are featured in the F.C.C. regenerator. D. W. F.

2657. Montreal east refinery includes unique cat-cracker. Anon. *Refiner*, 1951, **30** (7), 130–1.—After two years' construction and conversion Shell Oil Company of Canada officially opened its Montreal refinery in June. Capacity is 25,000 b.d. of crude, yielding gasoline, distillate fuel, heavy fuel oil, naphthas, and liquefied petroleum gases. The cat cracker of 10,000 b.d. capacity employs the new microspheroidal synthetic silica–alumina catalyst, which produces higher octane gasoline than natural catalysts and eliminates the necessity for electrical precipitations. Completely heat balanced, no preheater or catalyst cooler is required. R. W. G.

2658. Venice refinery undergoing expansion. V. S. Swaminathan. *Oil Gas J.*, 27.9.51, **50** (21) 104.—The Venice, Italy, refinery of the Industria Raffinezione Oli Minerali is being expanded to a capacity of 1,000,000 tons/yr, and will include plant for processing Middle East crude oil.

Facilities for despatch of products by ship, barge, and rail tank-car will be provided. G. A. C.

2659. Reforming, LPG recovery units installed in Trieste refinery. Anon. *Petrol. Process.*, 1950, **5** (11), 1187.—A brief description is given of the recently rebuilt refinery of "Aquila" Societa per Azione Tecnico-Industriale at Trieste, the rated capacity of which is 3000 b.d. An almost completed thermal reforming plant and propane–butane recovery unit are being installed, together with propane deasphalting, furfural solvent refining, M.E.K. dewaxing, contact filtration, and automatic blending plant for lube-oil treatment. D. W. F.

2660. Motor selection for hazardous locations. J. C. Linsenmeyer. *Petrol. Engr*, 1951, **23** (1), C20.—Descriptions of seven types of electric motors suitable for the various locations on a refinery as defined by the National Electric Code are given, and expedients which provide safe economic installation for different power requirements discussed. E. K. J.

2661. Refrigeration in the refining industry. Pt III. T. G. Hicks. *Refiner*, 1951, **30** (7), 147–9.—(See Abs. Nos. 1835 and 2103). This final article of the series discusses various phases of refrigeration system operation in process plants. The information should be of interest to both operators and designers. R. W. G.

2662. Unbalanced force reactions in control valve plugs and their influence on diaphragm motor design and operation. R. A. Rockwell. *Petrol. Engr*, 1951, **23** (2), C9–16.—Five types of single-seated plugs and six types of double-seated plugs were both tested in 4-inch valve bodies, and a series of stem-force readings at various valve lifts obtained. Results for single- and double-seated parabolic plugs are plotted and analysed. E. K. J.

2663. Nomograms for the solution of anchor bolt problems. A. I. Gartner. *Refiner*, 1951, **30** (7), 101–6.—The design of anchor bolts for tall towers and stacks is discussed. The old method is replaced by two nomograms which are applicable for more than eight bolts in the circle. Several illustrative examples are presented. R. W. G.

2664. Supports for vertical pressure vessels. Pt I. F. E. Wolosewick. *Refiner*, 1951, **30** (7), 137–40.—The first of a series of four, dealing with pressure-vessel support. Pressure vessels are often subjected to a wide range of working conditions which set up strains which may lead to failure of supports. In particular, ring supports, lug supports, and skirt supports are discussed, and lug reactions on vessels are considered. A résumé of studies and experiments is given. R. W. G.

2665. How to control welding quality. Anon. *Petrol. Process.*, 1950, **5** (11), 1192–5. (Condensed from "Welding quality control in a petroleum refinery" given at the Petroleum Mech. Eng. Conf, ASME New Orleans, Sept. 24–28.)—The essential requirements are presented for welding-quality control in a large refinery. Details are given of rigid qualification tests for refinery and contractors' welders. Welding inspection is continuous, and a plug sample is taken from each welder's work at least every three months. Substandard welds are cut out and re-welded. All welds can be identified with the welder, thus enabling a record to be kept. Special welding procedures for abnormal jobs are often worked out beforehand by the inspection group and job specifications issued. Electrodes are tested and evaluated in order that the suppliers of acceptable electrodes may be classified. D. W. F.

2666. Delignification of redwood cooling towers. M. Brooke. *Petrol. Engr*, 1951, **23** (4), C38.—Equilibrium and tower tests show that delignification of wood is a function of the pH of the water and independent of the salt concentration. (Author's Abstract.) E. K. J.

2667. Wood deterioration in cooling towers. D. R. Baker. *Petrol. Engr*, 1951, **23** (4), C76–82.—The chemical and biological processes which occur in wood under the various conditions found in cooling towers are analysed in detail, and methods of minimizing deterioration are suggested. It is found that coloured woods are usually more durable. E. K. J.

Distillation

2668. Oil from Alberta bituminous sand. W. S. Peterson and P. E. Gishler. *Petrol. Engr*, 1951, **23** (4), C66–74.—The recovery process involves direct distillation of oil from the sand particles covered with black viscous bitumen, in a fluidized-solids bed. Pilot-plant work was carried out to investigate oil yields and still capacities, the effect of conditions on the quality of oil produced, and finally to obtain heat and material balances. Optimum operating temp range was found to be 500° to 525° C, when yields of 85% of oil by vol were obtained. The effect of increase of operating temp was to decrease: (1) oil yield; (2) visc of the oil; (3) sulphur content from 5% in the bitumen to 4% in the oil; (4) asphaltene content almost to zero; (5) resin content by half. A still capacity of 5 tons feed day/cu. ft. of still-bed volume was established.
E. K. J.

2669. Introduction to the analytical treatment of the distillation and rectification of ideal multicomponent mixtures of materials. F. Florin. *Brennstoff-Chemie*, 1951, **32** (17–18), 258–62.—The first of a series devoted to the analytical treatment of the dist and rectification of ideal multi-component mixtures consisting of polar materials. The procedure developed mathematically and assisted by means of graphs is designed to make possible an exact calculation of the dist and rectification of mineral oils which can be regarded as almost polar materials. The basic conditions necessary for the construction of the evaporation equilibria of ideal multi-component mixtures which will be required in later articles are developed. Use is made of the previously developed function $1/\tau$.
R. T.

2670. Method of calculation for high purity fractionation. F. C. Fowler. *Petrol. Engr*, 1951, **23** (1), C35.—The use is explained of log-log plots of the McCabe–Thiele diagram for graphical solution of distillation problems for products of more than 99 mol-% purity. The less volatile component is the basis of the plot in order to spread the region of high concentration of the more volatile component. Curved operating lines are obtained so that several points must be determined before the lines are plotted. An illustration of the use of the plots is given.
E. K. J.

2671. Equilibrium flash vaporization of petroleum crude oils or fractions. D. F. Othmer, E. H. Ten Eyck, and S. Tolin. *Industr. Engng Chem.*, 1951, **43** (7), 1607–13.—A modified re-circulating equilibrium still is described which it is claimed can be used to obtain flash vaporization curves at atmospheric and sub-atmospheric pressures on petroleum fractions including fuel oils and crude oils. Data are presented for two naphthas, two gas oils, a de-asphaltized oil, and two crude oils.
F. M.

2672. A direct method for solving flash equilibrium calculations. P. M. Reilly. *Refiner*, 1951, **30** (7), 132–6.—The methods presented in this paper, which introduces a new approach to the trial-and-error methods, are applicable to many equilibrium flash calculations, and in most cases very considerably reduce the number of trials required.
R. W. G.

2673. Fractionating efficiency of various packings. M. Myles, J. Feldman, J. Wender, and M. Orchin. *Industr. Engng Chem.*, 1951, **43** (6), 1452–6.—Berl saddles, triple- and single-turn helices, glass spheres, and a commercial heli-grid column packing have been investigated at atm pressure using *n*-heptane–methyl *cyclo*hexane, and at reduced pressures using *n*-dodecane–*cyclo*hexyl–*cyclo*pentane as test mixtures. Efficiency, throughput, and hold-up were determined at various boil-up rates and various pressures from 20 to 760 mm Hg. Data are presented in graphical and tabular form which indicate that for the loose packings studied the column should be operated at close to maximum throughput capacity. The fixed-grid packing was superior to all the packings tested.
F. M.

2674. Patents. U.S.P. 2,561,624 (14.4.48; 24.7.51). J. M. Harrison, assr to Gulf Research and Development Co. *cyclo*Hexane is separated from benzene by distillation as a ternary azeotrope with water and *n*-propanol, and the azeotrope then washed with water.
V. P. P.

Ger.P. 807,812, 26.4.51. (H. B. Seebohm.) Victor Wolf Ltd. Procedure and apparatus for distillation and condensation.

Ger.P. 807,813, 26.4.51. Gebr. Sulzer AG. Apparatus for the separation of at least one component from a liquid mixture by distillation.
Brennstoff-Chemie, 23.5.51, **32** (9–10).

Ger.P. 815,799, 9.8.51. (L. Massiot.) Compt. Français de Raffinage. Distillation process and installation.

Ger.P. 817,592, 30.8.51. (K. W. Gee.) I.C.I. Ltd. Continuous distillation process.

Ger.P. 817,449, 23.8.51. (G. Butenuth.) A.G.f. Stickstoffdünger. Packing material for distillation columns and washing towers.

Ger.P. 817,918, 30.8.51. (H. U. Kohrt.) Metallgesellschaft. Process for separation of aromatic oxy-compounds from aq-solutions.
Brennstoff-Chemie, 19.9.51, **32** (17–18). R. T.

Absorption and Adsorption

2675. Significance of liquid-film coefficients in gas absorption. P. V. Danckwerts. *Industr. Engng Chem.*, 1951, **43** (6), 1460–7.—A mathematical treatment of gas absorption employing the concept that, in place of the " stagnant film " at the interface, the surface is continually replaced by fresh liquid. On this basis equations are derived for the mean absorption rates of various types of systems. F. M.

2676. Air–water contact operations in a packed column. F. Yoshida and T. Tanaka. *Industr. Engng Chem.*, 1951, **43** (6), 1467–73.—Experimental data are presented on humidification, water cooling, and dehumidification in columns packed with ceramic Raschig rings. The gas-film coefficients of heat and mass transfer were proportional to the gas rate and to the 0·2 power of water rate, while the liquid-film coefficient of heat transfer was proportional to the 0·8 power of water rate. Correlations are given which will facilitate the design of packed-column-type water–air contact apparatus. F. M.

2677. Continuous stripper for adsorption column effluent stream. R. L. Hopkins. *Industr. Engng Chem.*, 1951, **43** (6), 1456–8.—Designs are given for laboratory scale solvent strippers suitable for stripping a light solvent such as pentane, benzene, or *iso*propyl alcohol from samples containing these solvents. The strippers are used in conjunction with adsorption separation; the samples leaving the adsorption column after elutration with the light solvent pass directly into the stripper, the solvent being removed and recovered for use and the desorbed sample passing into receiving bottles. F. M.

2678. Patents. U.S.P. 2,561,822 (28.12.46; 24.7.51). M. Savoy, assr to Pure Oil Co. Olefins are separated from gaseous mixtures by absorption in a solution of a cuprous salt in an anhydrous acidified solvent consisting of an alkylolamine and a low boiling monohydric alcohol.

U.S.P. 2,560,448 (15.5.48; 10.7.51). W. C. Jones, assr to Standard Oil Development Co. High V.I. fractions are recovered from low V.I. solvent extracts of lub. oils by adding a light paraffin and contacting the mixture at 60° to 200° F with a bed of silica gel of particle size 28 to 350 mesh to selectively adsorb the low V.I. constituents. V. P. P.

Fr.P. 968,831. 6.12.50. Extraction Continue de Smet (S.A.). Process and installation for the continuous extraction of liquids from solid materials.
Brennstoff-Chemie, 18.7.51, **32** (13–14). R. T.

Solvent Extraction and Dewaxing

2679. Aromatic recovery by solvent refining. E. C. Medcalf, A. G. Hill, and G. N. Vriens. *Refiner*, 1951, **30** (7), 97–100.—The use of β, β^1-oxydipropionitrile, referred to as ODPN, in fractional solvent extraction is discussed. It provides means of

affording separations of mixtures unsuitable to distillation. As ODPN is high boiling and thermally unstable, the solute may be extracted with a paraffin with or without the addition of water at a temp above complete miscibility.

Data on the distribution coefficients for aromatic hydrocarbons, pyridine derivatives, alkylated anilines, and miscellaneous substituted aromatics are given. These vary from 0·05 for aniline to 20 for diethyl-o-toluidine. ODPN is an unusually selective solvent suitable for the extraction of high-purity aromatics from hydrocarbon mixtures. The ODPN/paraffin systems are suitable for separating wide varieties of similar organic compounds—*e.g.*, 2 : 6-lutidine and the picolines. R. W. G.

Cracking

2680. Twin air-lift Thermofor cat-cracking units onstream. Anon. *Petrol. Engr*, 1951, **23** (4), C11–16.—The design and operation is described of the Beaumont, Texas, T.C.C. unit which incorporates an air-lift for transporting regenerated catalyst back to the reactor. Another development is the use of the bead catalyst, a spherical form of the natural silica and alumina material which has a superior life-span and cracking efficiency. Recently chromic oxide has been added to increase the efficiency of regeneration. The many advantages to be gained by using the air-lift are emphasized in detail. E. K. J.

2681. Economics of petroleum coking for "cat cracking" feed preparation. J. W. Jewell and J. P. Connor. *Petrol. Process.*, 1950, **5** (11), 1199–207. (*Oklahoma State mtng, Amer. Inst. Chem. Engrs, Oct.* 7.)—The relative economic advantages of four conventional processes for preparing cat cracking feed stock from the same reduced crude are presented. Delayed coking is evaluated relative to vacuum flashing, vis-breaking, and propane decarbonizing. An overall economic summary is prepared in tabular form on an incremental basis, with delayed coking as base, for a completely processed crude. Comparisons are made of net incremental credits, immediate and after five years, for varying fuel oil values at a fixed coke value and vice versa. In general, the delayed coking processes have a higher earning power in a low fuel oil market or good coke market, though the higher investment required throws the indicated advantage to the other processes. D. W. F.

2682. Coker solves heavy fuel problem. A. L. Foster. *Petrol. Engr*, 1951, **23** (4), C53–62.—9000 b.d., of heavy residues are converted by a delayed coking operation to 5000 b.d. of gas oil and 300 tons/day of coke in twin drums 17½ ft dia and 96 ft high. The gas oil is subsequently cracked and the coke is sold. Details of plant operation are given, including the automatic removal of coke from the drums by means of two cutters, initial and main, which bore through the coke bed and dislodge the coke, using high-pressure water up to 1900 p.s.i.g. E. K. J.

2683. New ethylene process uses naphtha pyrolysis. Anon. *Refiner*, 1951, **37** (7), 122–3.—A brief description of the plant under construction for I.C.I. (the first of its kind) at Wilton, England. The plant will produce large quantities of very pure ethylene, besides motor gasoline and propylene, from naphtha charge. Temperatures employed range from 1700° F to −220° F. R. W. G.

2684. Vis-breaking of a high-vacuum petroleum residium. J. G. Allen, D. M. Little, and P. M. Waddill. *Refiner*, 1951, **30** (7), 107–14. (*Amer. Inst. Chem. Engrs, Kansas City*, May 16, 1951.)—Development through pilot-plant stage to commercial plant of vis-breaking high-vacuum residium is described. The topped crude is first vacuum distilled in a process under development operating at 100 to 800 μ (0·1 to 0·8 mm) absolute pressure. The gas oil free residium goes to the vis-breaker. Successful vis-breaking is dependent on: (1) high uniform heat-transfer rates and (2) high oil velocities through the cracking coil. The use of 1 to 2% water in the coil charge as diluent allows a substantial increase in cracking severity without an increase in coil coking. Vis-breaking is economically desirable over cutting back residium for fuel oil. R. W. G.

2685. Patents. U.S.P. 2,559,957 (27.9.46; 10.7.51). H. J. Hepp and M. O. Kilpatrick, assrs to Phillips Petroleum Co. Cracking and conversion of hydrocarbons using a pebble heater.

U.S.P. 2,561,419 (12.12.45; 24.7.51). A. H. Schutte, assr to Lummus Co. Continuous process for producing heating gas from heavy oil in presence of hot coke particles.

U.S.P. 2,561,334 (22.1.48; 24.7.51). V. O. Bowles and A. H. Schutte, assrs to Lummus Co. Conversion of heavy hydrocarbons into coke and lighter hydrocarbons.

U.S.P. 2,561,420 (7.1.49; 24.7.51). A. H. Schutte, assr to Lummus Co. Conversion of heavy residues into lighter liquid products with minimum coke formation.

U.S.P. 2,560,329 (15.6.46; 10.7.51). R. C. Brandon, assr to Standard Oil Development Co. Mono-alkyl naphthenes are dehydrogenated to alkyl aromatic hydrocarbons by passing the vapour over a catalyst consisting of Pt and/or Pd mixed with a microporous hydrous oxide carrier at 650° to 800° F.

U.S.P. 2,560,899 (30.4.47; 17.7.51). E. W. Shand, assr to Sinclair Refining Co. In a conversion process in which hydrocarbon charge oil is passed upwardly in vapour phase through a dense fluidized body of catalyst with a superimposed disperse phase from which catalyst is continuously withdrawn and regenerated, the regenerated catalyst is mixed with liquid charge oil under superatmospheric pressure and the pressure then suddenly reduced to flash the oil into vapour which with catalyst suspended therein is passed to the reaction zone.

U.S.P. 2,561,408 (25.5.48; 24.7.51). C. C. Peavy, assr to Houdry Process Corp. Process and apparatus for catalyst regeneration in which relatively cold oxygen-containing gas such as air is admitted to an intermediate section of the chamber and the stream of gas is split to flow in opposite directions through compact beds of moving contact mass in the upper and lower portions of the chamber, the gaseous combustion products being separately discharged. Process is suitable in systems circulating catalyst at high rates.

U.S.P. 2,561,396 (9.10.46; 24.7.51). G. L. Matheson, assr to Standard Oil Development Co. A mixture of finely divided solids is introduced into a non-transitory mass of relatively coarse solids up through which a gaseous fluid is blown so that the finely divided solids are stratified according to their buoyancies and are withdrawn as streams of different sized particles. V. P. P.

Fr.P. 969,997, 28.12.50. N.V. de Bataafsche Petroleum Maatschappij. Apparatus for carrying out catalytic reactions.

Fr.P. 970,034, 28.12.50. (R. T. Savage and R. C. Lassiat.) Comp. Française des Procédés Houdry. Apparatus for the catalytic conversion of hydrocarbons.

Ger.P. 806,455, 5.4.51. P. Kraus. Procedure for the cracking of liquid hydrocarbons in the electric arc furnace.

Ger.P. 807,814, 26.4.51. (L. Schertel) Th. Goldschmidt. Process for the production of nickel and nickel mixed catalysts, especially for the hydrogenation of organic compounds.

Ger.P. 807,417, 19.5.51. (G. Free) Badische Anilin- and Sodafabrik. Process for the cracking of asphaltic mineral oils, tars or their high-boiling fractions and residues.

Ger.P. 807,419, 19.4.51. (W. von Füner and W. Simon) Badische Anilin- and Sodafabrik. Process for the catalytic treatment of hydrocarbons, fats, oils, and waxes.

Brennstoff-Chemie, 23.5.51, **32** (9–10).

Fr.P. 964,849, 25.8.50. L. A. Ledoyen. Cracking of hydrocarbons.

Brennstoff-Chemie, 18.7.51, **32** (13–14). R. T.

Hydrogenation

2686. Patents. Ger.P. 817,596, 30.8.51. (F. Schnur.) Ruhrchemie A.-G. Procedure for carbon monoxide hydrogenation in the liquid phase.

Ger.P. 817,599, 30.8.51. (D. McNeil.) I.C.I. Ltd. Process for the hydrogenation of butadiene. (M. F. von Bethmann and E. Stiebling.)

Ger.P. 817,483, 23.8.51. Ruhrchemie A.-G. Procedure for the production of valuable soaps from the products of the catalytic hydrogenation of carbon monoxide.
Brennstoff-Chemie, 19.9.51, **32** (17–18). R. T.

Polymerization

2687. Patents. U.S.P. 2,559,985 (10.12.45; 10.7.51). L. C. Morris, assr to Phillips Petroleum Co. Hydrocarbon polymers formed in refining cracking distillates with clay are air-blown at 300° to 480° F for 3 to 6 hr to produce solid resins. V. P. P.

Fr.P. 965,025, 31.8.60. W. B. Shanley, assr to Universal Oil Products Co. Polymerization of olefin hydrocarbons.
Brennstoff-Chemie, 18.7.51, **32** (13–14). R. T.

Alkylation

2688. Lower acidity sulphuric acid alkylation. E. C. Hughes, D. G. Stevens, and F. Veatch. *Industr. Engng Chem.*, 1951, **43** (6), 1447–51.—Details are given of pilot-plant and full-scale plant alkylation of *iso*butane with mixed butenes using sulphuric acid of from 93 to 85% titratable acidity. It is shown that the slight drop in F_4 rating of the light alkylate with reduction in acid strength is accompanied by lower yields of light alkylate (F.B.P. 370° F), but that these losses are fully compensated for by the increased savings in acid consumption. F. M.

2689. Patents. U.S.P. 2,559,818 (31.12.48; 10.7.51). R. S. Hanmer, assr to Phillips Petroleum Co. Two-stage process for alkylating benzene with olefins present in a catalytically produced petroleum naphtha, b.p. 380° to 450° F, using HF catalyst.

B.P. 655,395 (U.S. 16.3.42; 18.7.51). Universal Oil Products Co. Alkylation of aromatic hydrocarbons with olefins at 200° to 450° C and <20 atm in presence of a calcined composite of a phosphoric acid and a siliceous adsorbent.

U.S.P. 2,562,608 (7.3.46; 31.7.51). L. U. Franklin, assr to Gulf Oil Corp. Recovery of sulphuric acid from alkylation sludges by either (1) extraction with liquid SO_2 at below 20° F to dissolve SO_2-soluble impurities but not the acid, further contacting the acid with fresh liquid SO_2 at $>70°$ F to dissolve the acid, separating the solution, cooling to below 20° F, and separating precipitated acid, or (2) contacting contaminated acid with liquid SO_2 at $>70°$ F, separating the solution from undissolved impurities, and cooling to below 20° F to precipitate the acid. V. P. P.

Chemical and Physical Refining

2690. Patents. U.S.P. 2,561,096 (15.10.47; 17.7.51). E. W. Clarke, assr to Atlantic Refining Co. Solvent refining of waxy mixtures with nitrobenzene.

U.S.P. 2,560,330 (24.9.48; 10.7.51). R. C. Brandon, assr to Standard Oil Development Co. Kerosine of low S content is produced by vapour phase treatment with bauxite at 600–850° F/0–50 p.s.i., followed by liquid phase treatment with SO_2.

U.S.P. 2,560,433 (16.7.48; 10.7.51). W. I. Gilbert and W. A. Horne, assrs to Gulf Research and Development Co. Desulphurization of hydrocarbon oil by contacting the vapours with an iron group metal or metal oxide composited with a silica-alumina catalyst in presence of hydrogen at 600° to 950° F., which is regenerated at $>1000°$ F.

U.S.P. 2,560,415 (14.12.48; 10.7.51). P. W. Cornell, assr to Gulf Oil Corp. In a hydrodesulphurization process in which high-boiling hydrocarbons containing S and hydrogen-containing gases under pressure are together contacted with an iron group metal oxide on a carrier, which is thereby converted to the sulphide, pressure drops and surges when the contact absorption process is renewed after regeneration of the catalyst are prevented by bringing the system to operating pressure by introducing a readily liquefiable saturated hydrocarbon gas.

B.P. 655,438 (28.7.48; 18.7.51). British Oxygen Co. Ltd., P. M. Schuftan, and J. B. Gardner. Water-vapour content of a gas at $<0°$ C is reduced by contact with a conc aqueous solution of a non-volatile, very sol substance, *e.g.*, an alkali metal hydroxide, at a temp above the eutectic point ($-10°$ to $-50°$ C). V. P. P.

Fr.P. 969,444, 20.12.50. L. G. R. Tompkins, assr to Standard Oil Development Co. Separation of organic compounds containing oxygen from hydrocarbon mixtures.

Fr.P. 970,690. 8.1.51. Anglo-Iranian Oil Co. Ltd. Process for catalytic desulphurization of kerosine and white spirits.

Fr.P. 969,716, 26.12.50. L. C. Fetterly, assr to N.V. Bataafsche Petroleum Mij. Fractional extraction and extractive crystallization of isomeric hydrocarbon mixtures.

Fr.P. 968,479, 28.11.50. F. W. B. Foster and F. R. G. Green, assrs to Anglo-Iranian Oil Co. Ltd. Catalytic desulphurization of naphthenic petroleum hydrocarbons.
Brennstoff-Chemie, 23.5.51, **32** (9–10).

Ger.P. 809,802, 23.5.51. L. Nettlenbusch and W. Sexauer, assrs to Concordia-Bergbau-A.-G. Process for the continuous purification of benzene hydrocarbons to pure products.

Fr.P. 964,355. 11.8.50. Centre National de la Recherche Scientifique. Separation of the resinification products from gasolines and other petroleum products.

Fr.P. 964,694, 22.8.50. L. C. Fetterly, assr to N.V. de Bataafsche Petroleum Mij. Fractional extraction and crystallization of hydrocarbon mixtures.

Italian P. 4346. Anglo-Iranian Oil Co. Catalytic desulphurization of petroleum hydrocarbons.
Brennstoff-Chemie, 18.7.51, **32** (13–14). R. T.

Ger.P. 816,101, 16.8.51. (L. C. Fetterly.) N.V. de Bataafsche Petroleum Mij. Process for the oxidation of hydrosulphides with the formation of neutral materials containing sulphur.

Ger.P. 814,593, 2.8.51. (R. M. LeRoy and T. S. Benson.) N.V. de Bataafsche Petroleum Mij. Procedure for the separation of an aromatic hydrocarbon from a mixture of hydrocarbons.

Ger. P. 816,093, 16.8.51. Dr F. Schwarz, Tubingen. Procedure for refining hydrocarbons and the like with sulphuric acid.
Brennstoff-Chemie, 19.9.51, **32** (17–18). R. T.

Special Processes

2691. Fischer-Tropsch synthesis in slurry phase. M. D. Schlesinger, J. H. Crowell, M. Leva, and H. H. Storch. *Industr. Engng Chem.*, 1951, **43** (6), 1474–9.—Details are given of pilot-plant investigation of the "slurry process" using finely divided iron catalyst suspended in oil and circulated by natural convection through a reactor in presence of synthesis gas. The effect of variations in operating temp and pressure upon the conversion of synthesis gas and the character of the products are recorded. Advantages of the process are improved temp control and mass transfer and greater flexibility of operation. F. M.

2692. Kinetics of coal hydrogenation. Conversion of asphalt. S. Weller, M. G. Pelipetz, and S. Friedman. *Industr. Engng Chem.*, 1951, **43** (7) 1572–5.—Asphalt obtained in the hydrogenation of coal has been subjected to further hydrogenation, batchwise at 400° C and 2500 p.s.i. hydrogen pressure. The conversion to oil and hydrocarbon gases appears to be first order with respect to asphalt remaining and also with respect to hydrogen pressure. The activation energy at 430° to 440° C is 36 k.cal per mole. Of the asphalt converted 90% is obtained as oil and 10% as hydrocarbon gases. F. M.

2693. Kinetics of coal hydrogenation. Conversion of anthraxylon. S. Weller, M. G. Pelipetz, and S. Friedman. *Industr. Engng Chem.*, 1951, **43** (7) 1575–9.—(See Abs. No. 2692.) The hydrogenolysis of a bituminous coal (antraxylon) has been studied

batchwise at 400° to 440° C with initial hydrogen pressures of 2500 p.s.i. The kinetics of the reaction are discussed, and it is shown that the conversion of coal to oil can be quantitatively described as coal → asphaltene → oil, both reactions being of the first order. F. M.

2694. Patents. U.S.P. 2,561,244 (25.10.47; 17.7.51). S. B. Sweetser, assr to Standard Oil Development Co. Two-stage process for hydrogenating carbon oxides in presence of a fluidized reduced iron catalyst to produce C_{10-17} alcohols in the first stage and normally liquid hydrocarbons in the second stage.

U.S.P. 2,560,345 (23.12.47; 10.7.51). C. E. Hemminger, assr to Standard Oil Development Co. In hydrocarbon synthesis from CO and H_2 using a fluidized iron catalyst, activity of the catalyst is increased and fragmentation reduced by (1) reducing the catalyst with H_2 to an oxygen content of 0 to 10 wt-% of Fe, (2) treating with synthesis gas sufficient to convert 20 to 50 wt-% Fe into iron carbide predominating in Fe_5C. (In U.S.P. 2,562,806, the fluidized iron catalyst is contacted in a conditioning zone with effluent gas from the synthesis zone containing CO and H_2 but no CO_2 to form iron carbide which is recycled. In U.S.P. 2,562,804, an iron catalyst with carbonaceous deposits is regenerated by heating above 1000° F in an atmosphere containing carbon oxides but no free oxygen.) V. P. P.

Ger.P. 817,305, 23.8.51. Standard Oil Development Co. Process for the extraction of an unsaturated hydrocarbon from a hydrocarbon mixture.

Ger.P. 817,918, 30,8.51. (W. Herbert.) Metallgesellschaft. Process for the separation of aromatic oxy-compounds from aq-solutions.
Brennstoff-Chemie, 19.9.51, **32** (17–18).

Ger.P. 805,516, 15.3.51. (E. Donath, O. Reitz, and W. Simon) Badische Anilin- and Sodafabrik. Process for the production of a hydrocarbon suitable as a solvent.

Ger.P. 805,520, 15.3.51. (W. Wolff, F. Aschatz and A. Burgard) Badische Anilin- and Sodafabrik. Solvent for organic materials.
Brennstoff-Chemie, 23.5.31, **32** (9–10).

Ger.P. 811,347, 14.6.51. Standard Oil Development Co. Process for the catalytic synthesis of hydrocarbons.

Ger.P. 811,230, 14.6.51. (O. Zechetmayr) Gutehoffnungshütte. Process for the oxidation of hydrocarbons, especially of methane to formaldehyde.

Ger.P. 809,812, 23.5.51. Solvay & Cie., Brussels. Process for the production of chlorinated hydrocarbons.

Ger.P. 810,399, 31.5.51. (H. Haendel). Maschinen Fabrik Esslingen. Process for the dissociation of a mixture of methane and carbon dioxide.
Brennstoff-Chemie, 18.7.51, **32** (13–14).

Ger.P. 816,854, 23.8.51. (D. H. P. Peel) I.C.I. Ltd. Conversion of pentamethylene naphthenes into aromatic hydrocarbons.

Ger.P. 816,694, 16.8.51. (A. Gislon and J. Quiquerez) Comp. Français de Raffinage. Method for the production of halogen derivatives of wax- or paraffin-type aliphatic hydrocarbons.

Ger.P. 817,304, 23.8.51. (H. Klein) Badische Anilin- and Sodafabrik. Method for production of unsaturated hydrocarbons.
Brennstoff-Chemie, 19.9.51, **32** (17–18).

Swedish P. 127,678, 21.3.50. R. W. Krebs, assr to Standard Oil Development Co. Hydrocarbon synthesis from carbon monoxide and hydrogen with fluid catalyst.
Brennstoff-Chemie, 23.5.51. **32** (9–10).

Fr.P. 960,312, 17.4.50. (J. C. Schiller) Standard Oil Development Co. Production of catalysts for the synthesis of hydrocarbons or compounds containing oxygen from CO and H_2.

Fr.P. 968,691, 1.12.50. S. D. Sumerford and F. J. Buchmann, assrs to Standard Oil Development Co. Synthetic production of hydrocarbons and compounds containing oxygen from CO and H_2.

Fr.P. 970,001, 28.12.50. J. C. Schiller and E. L. Ekholm, assrs to Standard Oil Development Co. Production of active iron catalysts for the synthesis of hydrocarbons from CO and H_2.

Fr.P. 969,523, 21.12.50. W. E. Spicer and U. R. McAdams, assrs to Standard Oil Development Co. Iron catalyst for the production of hydrocarbons from CO and H_2. *Brennstoff-Chemie*, 18.7.51, **32** (13–14). R. T.

Metering and Control

2695. Differential-pressure instruments for improving refinery processing. W. Kaplan and D. J. Bellam. *Oil Gas J.*, 20.9.51, **50** (20), 319.—Customary instrumentation at the Texas City refinery of Pan American Refining Corp. has been augmented by installation of differential-pressure indicators and recorders for operation of bubble-cap towers. Earliest application was to fluid catalytic cracking unit in 1946, making it possible to detect and correct tower flooding. Improved fractionation in a depropanizer unit followed use of the pressure instruments after a modification in the process.

A further application was in controlling foamover of the circulating amine solution in a desulphurization unit, an anti-foam being immediately added as soon as an increase of differential pressure is indicated.

Flow sheets show instrumentation in the units discussed, and operating conditions are tabulated for the processes concerned. G. A. C.

2696. Want a temperature record—dial it! E. J. Grace. *Petrol. Process.*, 1950, **5** (11), 1188–91. (*Fifth National Instrument Conf*, Buffalo, Sept. 19.)—Several remote temp-indicating systems have been developed from the first dial system designed and built by Sun Oil Co. Six variations on the telephone-type dial method of selecting any of a number of thermocouples on a process unit, with their different uses, are mentioned. Each system contains three separate circuits: a thermocouple-selecting circuit, a measuring or controlling circuit, and a checking circuit. The dial system can be used to connect any of a thousand thermocouples to the main indicator, the first two figures dialled selecting a particular block of ten points, the third selecting one of the ten. The basic unit of this is a ten-point stepping switch. Other methods mentioned are the scanning system, the continuous indicator system, and the application of the dial system to the remote setting of pneumatic controllers. Simplified circuit diagrams are given for the different systems. D. W. F.

Products

Chemistry and Physics

2697. The volumetric behaviour of carbon dioxide. B. J. Kendall and B. H. Sage. *Petroleum*, July 1951, **14** (7), 184–6. (API, Research Project 37.)—In the course of study of the volumetric and phase behaviour of binary hydrocarbon systems containing carbon dioxide it was necessary to establish the volumetric behaviour of pure carbon dioxide. Data from various sources have been collected, and the properties of the co-existing phases and the influence of pressure and temp upon the molal volume are given for pressure from 200 to 10,000 p.s.i. at temps between 40° and 460° F. Table I records the values of molal volume and the compressibility factor, which is defined by the equation $Z = \frac{PV}{RT}$.

Table II shows corresponding information about the dew-point gas and the bubble-point liquid for values of pressure and temp throughout the heterogeneous region at temps above 40° F. R. E. P.

2698. Catalytic esterification of olefins with organic acids. R. D. Morin and A. E. Bearse. *Industr. Engng Chem.*, 1951, **43** (7), 1596–600.—The esterification of olefins with various organic acids in the presence of a variety of catalysts has been studied. In particular, a mixed catalyst of boron fluoride in hydrofluoric acid is shown to be an excellent catalyst, and yields of 80% of *iso*propyl acetate have been obtained from propylene and acetic acid using this catalyst at 100° C with short reaction time.

F. M.

2699. Catalysis in fused salt systems. N. E. Norman and H. F. Johnstone. *Industr. Engng Chem.*, 1951, **43** (7), 1553–8.—A review with forty-eight references of the use of ionic melts as catalysts for reactions such as Friedl–Crafts, polymerization, and halogenation. Experimental investigation of the decomposition of acetylene and ethyl alcohol with various fused-salt systems is described. F. M.

2700. Graphical representation of extraction processes. A. V. Brancker. *Petroleum*, May 1951, **14** (5), 123–5.—Attention is drawn to the increasing importance of solvent-extraction processes, and an outline is given of some of the methods of graphical representation. The methods which apply normally to data obtained in the laboratory can be extended to the design of extraction equipment.

Graphical methods of representing equilibria in ternary and quaternary liquid systems are described, and practical examples based on the equilateral triangle and regular tetrahedron are discussed. R. E. P.

2701. Hydrogenation of petroleum nitrogen bases. R. J. Miller. *Industr. Engng Chem.*, 1951, **43** (6), 1410–14.—Mixed nitrogen bases extracted from thermally cracked California petroleum were reduced to a mixture comprising mainly secondary amines by several methods. Details are given of electrolytic reduction in a cell of 1200 ml capacity, of catalytic reduction over a catalyst of molybdenum sulphide deposited on activated carbon. Electrolytic reduction was unsatisfactory because of cathode poisoning. Catalytic hydrogenation gave a product of stable light straw colour claimed to consist essentially of secondary amines which was tested, with success, as a vulcanization accelerator, a lubricating-oil additive, a diesel-fuel additive, a flotation reagent, a fungicide, a solvent for the extraction of sulphur and acidic compounds, and as a wax solvent. F. M.

2702. Hydrogenolysis of thiophene over vanadium oxide. V. I. Komarevsky and E. A. Knaggs. *Industr. Engng Chem.*, 1951, **43** (6), 1414–18.—The hydrogenolysis of thiophene over vanadium oxide has been studied at 400° C and L.H.S.V. of 0·04 to 0·20. At low L.H.S.V. the product is essentially butane and hydrogen sulphide, but as the rate was increased the percentage olefin in the product increased rapidly. The catalyst activity was maintained over a period of 70 hr. The hydrogenolysis of *n*-butyl mercaptan was also studied. The process can be used for the desulphurization of benzene containing thiophene, a 5% by wt solution of thiophene in benzene desulphurized at 400° C and atmospheric pressure with a sulphur reduction of from 1·6 to 0·6%. Details of the apparatus used are given, and a suggested reaction mechanism is advanced. F. M.

2703. Nomograph for calculating contact time for vapour-phase reactions. J. N. Pattison. *Industr. Engng Chem.*, 1951, **43** (6), 1444–6.—An equation is derived relating the time of contact of a vapour-phase reaction to the reaction variables, and a nomograph is given to facilitate the solution of this equation. F. M.

2704. Phase equilibria in hydrocarbon systems. Volumetric and phase behaviour of the methane–*n*-butane–decane system. M. H. Reamer, B. H. Sage, and W. N. Lacey. *Industr. Engng Chem.*, 1951, **43** (6), 1436–44.—The volumetric behaviour of ten mixtures of the system methane–*n*-butane–decane has been measured at pressures up to 10,000 p.s.i. within the temperature interval 100° to 400° F. The mixtures were so chosen as to yield three fixed ratios of *n*-butane to decane so that the data might be more easily correlated. The composition of co-existing gas and liquid phases was determined for equilibrium at 250° F, and values are reported for pressures of 1000, 2000, 3000, and 4000 p.s.i. The phase-equilibrium measurements confirm the fact that the equilibrium ratio of a component in an aliphatic hydrocarbon mixture is markedly influenced by the nature and amount of the other components present. These data, coupled with earlier measurements for the same system, form a background from which the effect of composition upon the constants of an equation of state for mixtures may be evaluated. (Authors' Abstract.) F. M.

2705. Thermodynamic properties of propane. J. C. Chu, N. F. Mueller, R. M. Busche, and A. S. Jennings. *Petrol. Process.*, 1950, **5** (11), 1202–4.—Rigorous relations are used to calculate the thermodynamic properties of propane from data compiled.

Enthalpies, entropies, and specific volumes are shown at different temp and pressure in the vapour, liquid, and two-phase regions on a T-S diagram. The range covered is 100° to 460° F and 14·7 to 10,000 p.s.i. D. W. F.

2706. The fundamental equation of viscosity. M. Roegiers. *Petroleum*, June 1951, **14** (6), 149–50.—Author develops further the arguments derived from his theories of liquid and gaseous viscosity (*see* Abs. 2215, 2216, and 2217). Fundamental equations of liquid visc are criticized. The equation derived by Roegiers appears to be the same as the usual equation, but enunciation is *fundamentally* different: $1/\eta = A.e^{-E/RT}$. " Within the limits of ' normal fluids '—*i.e.*, gases or liquids, the molecules of which are exempt from directional forces—in equilibrium at temperature T, the log visc (η) varies linearly with the statistical intermolecular attraction energy (E) of the component molecules." A refers to the same entropy factor—a constant proper to each fluid—as symbol A which appears in the Boltzmann formula.

Experimental proof of theories is reported using binary systems, the components having widely different visc, *e.g.*, gasoline and Bright Stock. The results also prove that refined, Newtonian heavy petroleum fractions, notwithstanding their complex chemical character, are *physically* the most simple liquids. R. E. P.

Analysis and Testing

2707. Modern techniques in petroleum testing. I. Distillation (Pt 2). S. A. Ashmore and D. S. Vickery. *I.P. Review*, 1951, **5**, 271.—Article continues by describing different types of laboratory distillation apparatus and their use in petroleum testing. Batch distillation is used as a control test for a continuously operating distillation column. Such a continuous column when operated with max efficiency produces only two products; the taking off of side streams reduces efficiency by removing reflux from the plates. A typical fractionating column is described with particular reference to the details of its components: the column itself, the column insulation, and the column head. The method of determining the " boil-up " rate is described. Detailed instructions for an operator carrying out atmospheric and vacuum distillations are given. Mention is also made of various special columns, including rotary and continuous columns and apparatus for performing micro-distillations. R. H.

2708. Modern techniques in petroleum testing. II. Spectrometry in the petroleum industry. L. K. Maltby. *I.P. Review*, 1951, **5**, 315.—Both radiation spectrometry and mass spectrometry are utilized for analytical work in the petroleum industry. The first can be subdivided into emission, absorption, and Raman spectrometry. Emission spectrometry is mainly used in determining metallic constituents in crude oils, used and unused lub. oils, sludges, engine deposits, greases, etc. The material is electrically excited by arc or spark, and the resulting radiation (characteristic of the atoms of the molecule) concentrated into the spectrograph, where it is prismatically broken up into its component wavelengths, which are photographically recorded. The positions and intensities of the radiation so recorded are then interpreted to give the nature and quantities of the elements, each one of which has a characteristic emission spectrum. The quantitative accuracy is not so good, but there is a great time-saving relative to conventional analytical methods. Absorption spectrometry is based upon the reverse principle. The material, in solution form if necessary, is placed in the path of a beam of light and the absorbed wavelengths (utilized in exciting atoms or molecules to higher energy levels) recorded. By comparison with known absorption records, the qualitative and quantitative results are deduced. This principle is extended by using light covering particular wavelengths, *e.g.*, ultra-violet or infra-red. Absorption spectrometry can be used in gas analysis and in the analysis of liquid hydrocarbon mixtures. It is thus applicable to a number of petroleum problems. Raman spectrometry is carried out by mono-chromatic irradiation; subsequent emission of energy takes place, this being characteristic of the molecular structure. It is applicable to hydrocarbon analysis. Mass spectrometry is based upon the separation of ions according to their mass. It is used in hydrocarbon gas analysis. R. H.

2709. The particle size analysis of fluid cracking catalysts. Pt II. F. E. Ivey, Jr. *Refiner*, 1951, **30** (7), 141–5.—(*See* Abs. No. 2191.) The second of the series of three articles is concerned with Roller sub-sieve analysis. Some interesting figures on efficiency of separation are given. R. W. G.

2710. Further DIN drafts of test procedures for liquid fuels. W. Bieler. *Erdöl u. Kohle*, 1951, **4**, 569–78.—Following draft standards are reproduced : DIN 51752, boiling range of diesel fuels and similar materials. Procedure and apparatus are substantially those of ASTM D 158–41. DIN 51757, density of lubricating oils, liquid fuels, and related liquids. Method includes use of hydrometers, pyknometers, and Westphal balance. It has been drafted with the decisions of the International Conference on Oil Measurement (Brussels, 1949) in mind and is based on $d_{15/4}$. Shortened tables of temp-correction factors and conversions (API–sp. gr. 60/60° F–$d_{20/4}$–$d_{15/4}$) are given. DIN 51761, boiling range according to Kraemer-Spilker, applicable to aromatic hydrocarbons and covering range 75° to 105° C, 98° to 115° C, 60° to 210° C. DIN 51762, sulphuric acid reaction (for aromatic hydrocarbons). Equal vols of oil and H_2SO_4 ($96 \pm 0{\cdot}4\%$) are agitated for 5 min at room temp. Colour of acid layer is compared with that of $K_2Cr_2O_7$ solution (in 50% H_2SO_4). Result is expressed as concn (g/litre) of $K_2Cr_2O_7$. DIN 51769, TEL content of liquid fuels. Two alternative procedures are specified, either precipitation with Br and extraction of lead bromide with HNO_3 or the modified Schwartz method (IP 116/49). V. B.

2711. Determination of oil in paraffin wax. J. P. Hilfiger. *Chim. Anal.*, 1951, **33**, 292–4.—Procedure described is that of Layton (Abs. No. 239), which has been found very suitable for routine testing. Dimensioned diagrams of filter and centrifuge tube used are given. V. B.

2712. Determination of organic sulphur in liquefied petroleum gases. E. Raimondo, C. Siniramed, and E. Gianoli. *Riv. Comb.*, 1951, **5** (8), 395–403.—Different methods used for the determination of organic sulphur in liquefied petroleum gases are reviewed.

A new apparatus is described which is particularly useful for the determination of organic sulphur in liquefied petroleum gases. Very small percentages of sulphur can be determined by burning considerable amounts of gas; the trouble caused by the formation of relatively large quantities of condensed water is overcome by a simple device. (Authors' Abstract.)

2713. Determination of sulphur in light distillates by lamp combustion and potentiometric titration. A. Girelli and C. Siniramed. *Riv. Comb.*, 1951, **5** (8), 411–15.—ASTM D 90–50T apparatus for sulphur determination in petroleum light distillates by lamp combustion has been modified in order to enable automatic potentiometric titration of Na_2CO_4 solution after lamp combustion of sample. (Authors' Abstract.)

2714. Thermo-couple-type combustible gas analyser expands field of application. F. Taylor, Jr. *Refiner*, 1951, **30** (7), 124–5.—The presence of combustible mixtures can be a high hazard in process-plant operating areas and in tankage or equipment opened for clean-out or maintenance. Convenient and accurate methods of measurement for combustibility are thus a real value to operating groups. This new instrument is said to incorporate these qualities. (Author's Abstract.) R. W. G.

2715. I.F.P. No. 3–1 detector of hydrocarbon leaks. R. Monicard. *Rev. Inst. franç. Pétrole*, 1951, **6**, 324–30.—Instrument previously described (*see* Abs. No. 2755—1950) has been modified in several respects, including portability. Gas is fed to combustion chamber by battery-driven fan at 6 ml/sec. Detector was checked on various gases, sensitivity (% gas in air) being propane 0·02, town gas 0·05, H_2 0·05, CH_4 0·02, gasoline 0·01. Instrument can be used as detector and analyser both in refinery and field, latter is simpler, as detector can then be specially adjusted to CH_4. Sensitivity is greater than M.S.A. (No. 2) explosimeter. Detailed description is given of use of detector for finding leaks in natural-gas lines, including use when operator is walking. Circuit diagram and calibration curves are given. V. B.

Crude Oil

2716. Patents. Ger.P. 807,418, 19.4.51. (G. Free) Badische Anilin- and Sodafabrik. Method for the processing of asphaltic and resinous mineral oils, tars or their high-boiling fractions.

Brennstoff-Chemie, 23.5.51, **32** (9–10). R. T.

Gas

2717. Utilization of natural gas in Canada. G. S. Hume. *Engineering J.*, Sept. 1951, **34** (9), 853–8.—An outline is given of the availability of supply and the markets that are within possible economic reach of the areas in which natural gas is found. Appraisals of Alberta's natural-gas reserves by the author and by others are summarized, and they are compared with Alberta's domestic requirements. The various pipeline projects for exporting natural gas are given, and discussed as to the economic advantages and the dangers arising from each. The alternate proposals for importing Texas gas are discussed, and the benefit of a supply of natural gas to Ontario and Quebec is assessed. W. H. C.

2718. Patents. Ger.P. 816,543, 18.6.51. (B. Kellner and H. Müller) R. Decker and H. Holt, Muchen. Procedure for drying acetylene.

Ger.P. 817,451, 23.8.51. (W. van Loon) Staatsmijnen, Limburg. Procedure and installation for carrying out reactions of gases with fine-grained materials.

Ger.P. 816,872, 23.8.51. Dr W. Heimberger, Bayreuth. Apparatus for the separation of sulphur from gases.

Fr.P. 979,777, 2.5.51. Saar-Ferngas A.G. Process and apparatus for gas purification.

Fr.P. 982,432, 11.6.51. Staatsmijnen in Limburg. Process for separating carbon monoxide from a gaseous mixture containing carbon monoxide and oxide of nitrogen. *Brennstoff-Chemie*, 19.9.51, **32** (17–18).

Fr.P. 970,040, 28.12.50. F. T. Barr, assr to Standard Oil Development Co. Water gas production.
Brenstoff-Chemie, 23.5.51, **32** (9–10).

Engine Fuels

2719. National motor-gasoline survey winter 1950–51. O. C. Blade. *U.S. Bur. Mines Rep. Invest.* No. 4089, July 1951.—Analytical data are recorded of 4092 samples of regular and premium motor gasolines, representing the products of 135 companies during the winter 1950–51. Seasonal trends over the years are summarized. Both grades had slightly higher research and motor method O.N.s than those sold during the preceding summer, 1950, when record levels were attained. It is remarked that the winter grades have lower T.E.L. contents than the summer. It is generally agreed that the lighter (lower-boiling) components required to " tailor " a motor fuel to winter specifications are in themselves relatively higher in knock value, and therefore cause the finished fuel to require less T.E.L. W. H. C.

2720. Turbulence and flame propagation in pre-mixed gases. D. B. Leason. *Fuel*, 1951, **30** (9), 233–9.—It is postulated that the effects of turbulence on flame propagation are (1) to increase the rate of burning by increasing the flame front area and (2) to increase the burning velocity by increasing the rate of diffusion of active species (or heat) into the unburnt gas. Experimental results from two different types of apparatus are compared with those calculated according to this hypothesis and are in good agreement. (Author's Summary.) W. H. C.

2721. Patents. U.S.P. 2,560,489 (3.6.47; 10.7.51). H. G. Smith and T. L. Cantrell, assrs to Gulf Oil Corp. Leaded gasoline stabilized with a tri-alkylphenol and an azomethine.

U.S.P. 2,560,904 (28.7.50; 17.7.51). R. Sugimoto, assr to Ethyl Corp. Diesel fuel containing a *gem*-dinitro*cyclo*alkane of 5 to 10 C atoms, *e.g.*, 1 : 1-dinitro*cyclo*hexane, to decrease the ignition delay period.

U.S.P. 2,560,602 (9.4.46; 17.7.51). W. A. Schulze and J. E. Mahan, assrs to Phillips Petroleum Co. Gasoline composition of improved rich mixture performance and lead response consisting of C_{5-8} branched-chain paraffins and 1 to 20 vol-% of a picoline. (A similar composition in U.S.P. 2,560,898 contains pyridines with at least two nuclear methyl groups.) V. P. P.

Fr.P. 967,499, 3.11.50. E. D. Reeves, assr to Standard Oil Development Co. Additive for motor fuel.
Brennstoff-Chemie, 23.5.51, **32** (9–10).

Ger.P. 817,299, 23.8.51. Fritz Winkler, Leisnig (Sa.). Procedure for the production of generator fuel.

Ger.P. 817,590, 30.8.51. P. Hoppe, Embsen b. Lüneburg. Procedure for the production of high-grade fuel.

Fr.P. 979,990, 7.2.51. Manuf. Générale de Munitions. New solid fuel and its manufacture.
Brennstoff-Chemie, 19.9.51, **32** (17–18). R. T.

Lubricants

2722. Gear lubricant—constructional gear material. H. Blok. *Ingenieur*, 28.9.51, **63** (39), O.53.—The power-transmitting capacity of highly loaded tooth gears is influenced by their lubrication to such an extent that great constructional value can be ascribed to the gear lubricant. These constructional properties manifest themselves both in the dispensing of the lubricant and in the state of lubrication of the tooth faces. The visc at the operating temp is the essential constructional property of a gear oil so far as this is concerned in the dispensing of the oil, *e.g.*, flinging off of the oil from the tooth faces, and the power losses due to the expulsion of the oil from between the meshing teeth and the churning of the gears in the oil-bath. Boundary lubrication is characteristic for many highly loaded gears, but satisfactory potentialities are inherent in this type of lubrication, particularly when protection against scuffing by means of E.P. oils is concerned. For purely mineral oils it is not visc at the operating temp, but visc *grade* that is to be considered as approx indicative of the protection they afford against scuffing. R. R.

2723. Some higher alkyl naphthenates as lubricating oil for fine instruments. T. Kuwata, S. Noguchi, and H. Ando. *Bull. Chem. Soc. Japan*, July 1951, **24** (3), 157–60.—The syntheses of 2-ethylhexyl, *n*-octyl, decyl, lauryl, cetyl, oleyl, and sperm esters of naphthenic acid and lauryl (industrial) and sperm liquid esters of crude naphthenic acids are described, and their properties are reported. They have a pale yellowish colour, low visc, low evaporation rate, low solidification point, high fl. pt. high V.I., high thermal stability, and slow spreading velocity on metal or glass surfaces. These higher fatty alkyl esters possess excellent qualities as lubricating additives for the lubrication of delicate instruments. W. H. C.

2724. Lubrication of refinery equipment. Pt I. C. M. Larson. *Petrol. Engr*, 1951, **23** (1), C5.—An analysis is made of the requirements of lubricants for steam, gasoline, and diesel piston engines and steam turbines, with particular reference to economic operation. Troubles associated with each class of prime mover are described, and reasons for choice of lubricant are given. E. K. J.

2725. Lubrication of refinery equipment. Pt 2. C. M. Larson. *Petrol. Engr*, 1951, **23** (2), C19–26.—The analysis of lubricating requirements is continued for steam pumps, air compressors, roller chains, gears, and electric motors, recommendations being made for the most suitable lubricant. The various pieces of mechanical equipment found in a typical refinery are grouped in a chart according to the lubricant required. E. K. J.

2726. 10 ways to stop losses in lubricating plant equipment. Anon. *Petrol. Process.*, 1950, **5** (10), 1068–9.—A condensed version is given of a paper entitled "Refinery lubrication—a management problem" presented by L. F. Jahnke before a Petroleum Mechanical Engineering Conference of the Amer. Soc. of Mech. Engrs held during Sept. 24 to 28 in New Orleans. Ten factors are listed as a means of checking lubrication practices in refineries to form the basis of a cost or efficiency estimate of current methods. D. W. F.

2727. Patents. U.S.P. 2,560,588 (29.12.45; 17.7.51). J. C. Munday and D. T. Rogers, assrs to Standard Oil Development Co. Waxy mineral lub. oil containing a polymer of an alkyl fumarate as pour point depressor.

U.S.P. 2,562,808 (21.8.48; 31.7.51). L. A. Mikeska, assr to Standard Oil Development Co. Lubricant having a low stable pour point consisting of a waxy mineral lub. oil and a wax-phenol ester of a C_{12-18} alkyl succinic acid.

U.S.P. 2,562,776 (24.6.48; 31.7.51). E. B. Cyphers and J. H. Bartlett, assrs to Standard Oil Development Co. Lub. oil containing a condensation product of a C_{6-22} dialkyl dithiophosphate alkali metal salt and a copolymer of a C_{6-22} aliphatic chloromaleate and vinyl acetate.

U.S.P. 2,562,800 (18.12.47; 31.7.51). E. Lieber, assr to Standard Oil Development Co. Lubricant containing reaction product of a sulphur chloride and a ketone R.CO.Ar, where R = $>C_{10}$ aliphatic group, Ar = aromatic group.

U.S.P. 2,562,829 (28.7.49; 31.7.51). L. W. Sproule and L. F. King, assrs to Standard Oil Development Co. E.P. lubricant containing sulphurized and phosphorus sulphide treated fatty oil, a chlorinated hydrocarbon of mol. wt. < kerosine (40% Cl) and manganese naphthenate as anti-rust agent.

U.S.P. 2,560,956 (3.5.47; 17.7.51). G. C. Johnson, assr to Socony-Vacuum Oil Co. Inc. Mineral lub. oil of improved V.I. containing a polymeric thiophene and/or mono alkyl thiophene obtained by contact of monomer with silica–alumina at 20° to 200° C.

U.S.P. 2,561,773 (28.10.47; 24.7.51). F. B. Augustine, assr to Socony-Vacuum Oil Co. Inc. Lubricant of improved resistance to corrosion and sludge formation containing the reaction product of a diester of dithiophosphoric acid and pinene.

U.S.P. 2,561,780 (1.9.48; 24.7.51). J. W. Brooks, assr to Socony-Vacuum Oil Co. Inc. Mineral oil stabilized against oxidation with a β-thienylthioalcohol.

U.S.P. 2,562,144 (24.10.46; 24.7.51). D. Harman and G. L. Perry, assrs to Shell Development Co. Lubricant prepared by heating S with a polyether R_1–[–O.R.S.R.–]$_n$–ORSH, wherein R_1 is an unsaturated aliphatic hydrocarbon radical, each R is a divalent aliphatic hydrocarbon radical and n is an integer.

U.S.P. 2,560,542 (7.6.47; 17.7.51). J. D. Bartleson and E. C. Hughes, assrs to Standard Oil Co. Mineral lub. oil containing 0·25 to 0·5 wt-% chromium naphthenate and 0·25–0·5 wt-% manganese naphthenate and/or copper oleate to promote clean burning, and 1 wt-% reaction product of P_2S_5 with hydrogenated sperm oil as anti-oxidant.

U.S.P. 2,560,543–8 (29.5.48; 17.7.51). J. D. Bartleson, assr to Standard Oil Co. U.S.P. 2,560,543. Oxidation resistance of lub. oil is improved by heating with 0·1 to 0·75 wt-% of a phosphorus sulphide at 275° to 450° C. This process is combined in the other patents with pre-refining of the oil, treatment of the product with a base or clay or with combinations of these processes.

U.S.P. 2,562,814 (5.3.49; 31.7.51). R. O'Halloran, assr to Standard Oil Development Co. Grease consisting of lub. oil thickened with 5 to 20 wt.-% high-mol.-wt. oil-sol metal pet sulphonate, 0·5 to 15 wt-% oil-insol metal salt of relatively low-mol.-wt. acid and 0·1 to 5 wt-% of a polyhydric alcohol ester of a C_{12-24} acid.

U.S.P. 2,562,844 (22.7.47; 31.7.51). D. Harman, R. E. Thorpe and S. K. Talley, assrs to Shell Development Co. Metal-working lubricant comprising an aqueous medium containing a bis (hydroxyalkyl) sulphide and an amine nitrite.

U.S.P. 2,560,193 (27.12.47; 10.7.51). B. H. Shoemaker, assr to Standard Oil Co. Substances causing haze when wax-free pet oils are chilled are removed by treatment with urea.

U.S.P. 2,560,986 (7.3.47; 17.7.51). F. P. Richter, assr to Socony-Vacuum Oil Co. Inc. Mineral oil containing as a detergent, a barium and/or magnesium salt of a product obtained by converting C_{15-36} pet hydrocarbon mixtures into Grignard compounds, treating with CO_2, and hydrolysing to produce carboxylic acids.

B.P. 655,068 (U.S. 14.2.47; 11.7.51). Standard Oil Development Co. Mineral or synthetic lub. oil composition containing a copolymer of at least one maleic acid ester with at least one vinyl ester or ether, the copolymer having a number of side chains averaging 4–18 C atoms.

B.P. 655,093 (U.S. 20.3.47; 11.7.51). Socony-Vacuum Oil Co. Inc. Mineral lub. oil composition containing as pour depresser and V.I. improver, the reaction product of maleic anhydride and styrene, which product has been esterified, preferably with a C_{12-14} aliphatic alcohol.

B.P. 654,968 (U.S. 30.3.39; 4.7.51), Anglamol Ltd. Liquid hydrocarbons are stabilized against oxidation or polymerization with an oil-soluble ester salt or halogenation product of a P-containing ester obtained by action of PCl_3 on cyclohexanol and/or its homologues.

B.P. 655,464 (U.S. 29.3.47; 25.7.51). E. M. Kipp and Aluminium Co. of America. E.P. lubricant comprising a poly*iso*butylene (mol. wt. 150–1500) containing 0·005–2 wt-% BF_3.

B.P. 654,930 (8.8.46; 4.7.51). Textile Oils Ltd., C. W. A. Munday, and R. H. H. Morley. Textile lubricant comprising by weight: mineral oil (20 to 80%), oleine acids (10 to 65%) and a scouring assistant (5 to 50% of oil) which may be a partial ester of a polyhydric alcohol and a higher fatty acid, wool fat acid or liquid rosin acid, and/or a higher fatty alcohol, stearol or wool fat alcohol.

B.P. 655,011 (31.12.47; 4.7.51). Standard Oil Development Co. Normally liquid or semi-fluid lub. composition acquiring grease-like consistency on mechanical working consists of mineral lub. oil and 8 to 35 wt-% of a mixture of alkali metal salts of low-mol-wt carboxylic acids of 2 to 4 C atoms (*e.g.*, acetic, acrylic acid) and alkali-metal soaps of high-mol-wt fatty acids of 12 to 22 C atoms (*e.g.*, fish oil fatty acids).

B.P. 655,325 (U.S. 26.12.46; 18.7.51). D. E. Adelson, assr to N.V. de Bataafsche Petroleum Mij. Oleaginous substance stabilized with reaction product of a compound containing an ethylenic bond and/or a carbonyl radical with H_2S. V. P. P.

Fr.P. 976,342, 16.3.51. C. C. Wakefield and Co., Ltd. Improvements applied to lubricating compositions.

Fr.P. 977,498, 2.4.51. Soc. Chimique de la Grand-Paroisse. Procedure for the treatment of bituminous limestones, impregnated sandstones, etc., for the production of lubricating oils.

Fr.P. 979,238, 24.4.51. Socony-Vacuum Oil Co. Synthetic lubricants and their mode of preparation.

Brennstoff-Chemie, 14.11.51, **32** (21–22).

Fr.P. 979,344, 25.4.51. Standard Oil Development Co. Greases for high temperatures.

Fr.P. 980,332, 10.5.51. Comp. Française de Raffinage. New synthetic lubricant.

Fr.P. 980,358, 11.5.51. Process and apparatus for the manufacture of lubricants.

Fr.P. 981,206, 23.5.51. C. J. C. D. F. Coupard. Procedure for the preparation of lubricating oil accompanied by carburetants, solvents, and contingently by resins, plastics, insulators, and lacquers starting from the products of hydrogenation of acetylene.

Ger. P. 816,102, 16.8.51. (J. Altpeter and E. Kranepuhl) LIAS Ölschiefer-Forschungs-G.m.b.H. Procedure for the production of viscous oils.

Ger.P. 816,251, 16.8.51. (H. P. Fiedler) Vasenol-Werke. Procedure for the production of refined, pharmaceutically valuable shale-oil products.

Ger.P. 818,071, 30.8.51. Standard Oil Development Co. Lubricating oil synthesis. *Brennstoff-Chemie*, 19.9.51, **32** (17–18).

Fr.P. 968,596, 30.11.50. R. C. Barton, R. F. Bergstrom, and J. M. Plantfeber. N.V. de Bataafsche Petroleum Mij. Additive for mineral lubricating oils. *Brennstoff-Chemie*, 23.5.51, **32** (9–10).

Ger.P. 810,055, 31.5.51. (G. Lange) Chemie G.m.b.H. Witten. Highly viscous lubricants.

Fr.P. 968,565, 30.11.50. "Shell" Refining and Marketing Co. Ltd. Lubricating products with a mineral oil base.

Fr.P. 968,596, 30.11.50. N.V. de Bataafsche Petroleum Mij. Lubricating composition.

Fr.P. 969,181, 15.12.50. F. M. Leger and A. N. Sachanen, assrs to Socony-Vacuum Oil Co. Inc. Production of viscous lubricating oils. *Brennstoff-Chemie*, 18.7.51, **32** (13–14). R. T.

Bitumen, Asphalt, and Tar

2728. The components of the bitumen in Athabasca bituminous sand and their significance in the hot water separation process. D. S. Pasternack and K. A. Clark. *Research Council of Alberta*. Rep. No. 58, Jan. 1951.—An investigation of the bitumens throughout the Athabasca bituminous area shows no appreciable variation in their ultimate composition, which substantiates the deduction that the bitumens are of similar origin. Results are tabulated for nine samples from Bitumount and one from Abasand. The main difference between the analyses is variation in the proportion of asphaltenes with corresponding variations in the proportion of oily constituents. However, when calc as a % of asphaltenes plus resins the asphaltenes are remarkably const. The bitumen at Abasand is highly viscous, primarily due to a lower proportion of oily constituents. The ultimate composition of some bitumens in the Bitumount bituminous sand beds differs somewhat from that of other beds in the section; this slight variation does not affect the hot water separation. In the extraction of asphaltenes with benzene the very fine mineral matter which passes through the pores of the thimble is closely associated with the asphaltenes which remain after removal of the "difference resins." A method is presented for avoiding the formation of troublesome emulsions when determining the proportion of saponifiable matter in the bitumen. R. T.

2729. Durability properties of asphaltic bitumen: A review of the literature. S. L. Neppe. *Trans. S. African Inst. Civil Engrs*, Sept. 1951, **1** (7), 195–221.—Literature on the hardening of bitumens is reviewed, with particular reference to critical penetration and ductility limits as affecting the disintegration of road surfaces. A critical survey is given of the methods for the evaluation of binder durability, covering the action of heat on thin films, oxidation, and sunlight, with special emphasis on ultraviolet and infra-red radiations. Certain anomalies leading to incorrect interpretation of results in the graphical representations of experimental data by certain other investigators are pointed out, and the author illustrates the practical value of his conception of "true penetration." The term "percentage drop in penetration," as used in most bitumen specifications, is shown to be fundamentally unsound, and should be replaced by the more logical "percentage drop in log true penetration." 107 references are given. W. H. C.

2730. The use of natural rubber in asphalt road construction. H. W. T. Minnaar. *Trans. S. African Inst. Civil Engrs*, Sept. 1951, **1** (7), 224–6.—Some brief notes are given of the use of products from natural rubber incorporated in asphaltic road materials, viz., "Pulvatex" and "Mealorub," and the laying of (1) a spray coat of asphalt containing 5% of "Mealorub" and (2) a premixed carpet of ¾-inch size stone containing 5% (by wt of the bitumen content) of "Mealorub," in two streets in Bloemfontein. Mention is also made of a rubber product called "Onazote," an expanded ebonite, which is becoming a very popular insulating material. W. H. C.

2731. Coal tar coating materials and plastic masses and their application for corrosion and structure protection. K. Meyer. *Bitumen, Teere, Asphalte, Peche*, 1951, **8** (2), 204–7.—(*See* Abs. No. 2414.) The mechanical properties of special pitches are shown

to be superior to those of ordinary coal-tar pitch or bitumen in a large variety of applications. Sp applications are the protection of steel pipes and structures. Compositions for seasonal application, with special instructions for their use *in situ* or in the works, are tabulated. Sp properties are resistance to water and bacterial influence, and root strength. These are valuable assets for protecting underground pipes against rusting, particularly in marshy land, and underground structures against water pen. No objectionable smell or taste is observed in water which comes into contact with this material. Other successful applications are the sealing of tramlines, the filling of joints in paved or cement-concrete street surfaces, for roofing compositions, wagon-cover impregnation, and acid-resistant vessel bottoms, also airfield runways. On airfields and streets the coatings are shockproof and unaffected by petrol and benzene.
R. T.

2732. Patents. U.S.P. 2,560,650 (1.9.48; 17.7.51). M. Kronstein. Asphaltic bitumen is heated with ≤ 4 wt-% of a peroxide to produce a solid bitumen insoluble in naphtha and toluene. V. P. P.

Ger.P. 817,150, 23.8.51. (H. Franck) Ges.f. Teerverwertung. Procedure for obtaining pure tar hydrocarbons.

Fr.P. 977,468, 2.4.41, and Fr.P. 982,484, 11.6.51. Schistes, Carburants et Lubrifiants S.A. Improvements in the distillation of bituminous schists.

Fr.P. 977,989, 9.4.51. Procedure for the low-temp distillation of bituminous schists.

Swiss P. 271,374, 16.1.51. N.V. Philips' Gloelampenfabrieken. Protective coatings for metals, textile impregnators, and electro-insulators of asphalt bitumen.
Brennstoff-Chemie, 19.9.51, **32** (17–18).

Dutch P. 64,163, 15.9.49. J. C. Derksen, assr to N.V. Philips' Gloelampenfabrieken, Eindhoven, Holland. Addition of 5 to 10% of solid or semi-solid polyethylene as powder or solution to molten or dissolved bitumen reduces brittleness and raises soft. pt. Usual fillers or synthetic resins can be added to the product.
Bitumen, Teere, Asphalte, Peche, 1951, **9** (2).

Finnish P. 24,682, 30.11.50. M. Ilveskorpi. Coating material for roads.
Brennstoff-Chemie, 18.7.51, **32** (13–14). R. T.

Special Hydrocarbon Products

2733. Retardation of viscosity rise of asphalt solvent blends. A. J. Hoiberg. *Industr. Engng Chem.*, 1951, **43** (6), 1419–23.—Experimental results are recorded of a study of the effect of certain polar compounds upon the visc rise with time of a series of five cut-back asphalt–solvent blends. The additives studied included amines, alcohols, and carboxylic acids. Alkyl amines of mol. wt. in the neighbourhood of 200 to 250 were found to be the most effective additives. The percentage increase in visc (I) was related to time (T) by the equation $I = kT^a$, where a and k are constants for a given cut-back. F. M.

2734. Patents. U.S.P. 2,560,373 (29.3.48; 10.7.51). A. J. Shmidl, assr to Standard Oil Development Co. A hydrocarbon fraction b.p. 380° to 390° F containing 18% durene (1 : 2 : 4 : 5-tetramethyl benzene) is chilled to 0° to 32° F, the durene-containing crystals formed being separated and purified by sweating at *ca* 85° F.

U.S.P. 2,561,996 (21.8.47; 24.7.51). S. P. Robinson, assr to Phillips Petroleum Co. Acetylene production by partial oxidation of hydrocarbons of low C content.

U.S.P. 2,562,068 (26.4.48; 24.7.51). M. Souders, assr to Shell Development Co. Separation of xylene isomers by solvent extraction.

U.S.P. 2,562,217 (29.5.47; 31.7.51). L. Schmerling, assr to Universal Oil Products Co. A saturated hydrocarbon of $>C_2$ is condensed with a polychloro mono-olefin to form HCl and a chlorolefin (U.S.P. 2,562,369), which is condensed with an *iso*paraffin in presence of a Friedel–Crafts catalyst to produce a saturated hydrocarbon.
V. P. P.

Derived Chemical Products

2735. Ethylene oxide—a versatile chemical. A. J. Lowe and F. Chapman. *Petroleum*, July 1951, **14** (7), 182–3.—Reaction between ethylene and hypochlorous acid gives a solution of ethylene chlorhydrin, which is reacted with lime to give ethylene oxide. This can be recovered from the resultant aqueous solution by careful fractionation and purified by distillation. It can be handled with safety, providing certain regulations for its handling and processing are obeyed.

Ethylene oxide is very reactive. It is capable of reacting with amines, alcohols, mercaptans, organic acids, and with almost any molecule containing a replaceable hydrogen atom, to produce important intermediates for the manufacture of solvents, plasticizers, waxes, detergents, surface-active agents, cosmetics, drugs, fumigants, and plastics.

Cost of production is to a considerable extent dependent on the cost of and supply of ethylene. With the full production of ethylene envisaged in various projects in Britain, a reduction in price can be anticipated. An assured supply of ethylene will allow ethylene oxide and its derivatives to be developed in the U.K. R. E. P.

2736. Petroleum chemicals in the textile industry. Anon. *Petroleum*, May 1951, **14** (5), 126. (*Summary of address given by J. A. Hepworth to Rossendale Textile Soc.*)—In general, two types of chemicals used in the textile industry are derived from petroleum:

(1) The type obtained as a by-product during petroleum refining—*e.g.*, naphthenic acid and sodium naphthasulphonate.

(2) The more important types which are manufactured or synthesized in which petroleum is a raw material—*i.e.*, solvents such as acetone, detergents such as the secondary alkyl sulphonates, and chemicals such as acetic anhydride and acetic acid used in the manufacture of acetate rayon.

The author states the synthetic detergents made from petroleum are of great value, principally because of their superior stability and solubility over normal soaps.

R. E. P.

2737. Patents. U.S.P. 2,562,857 (10.3.48; 31.7.51). A. Cambron and F. L. W. McKim, assrs to Honorary Advisory Council for Scientific and Industrial Research, Canada. Production of ethylene oxide by reaction of ethylene and oxygen in presence of an alloy of silver with an alkaline earth metal. (Production of the alloy is claimed in U.S.P. 2,562,858.)

U.S.P. 2,561,787 (15.6.49; 24.7.51). W. I. Denton and R. B. Bishop, assrs to Socony-Vacuum Oil Co. Inc. Olefins of >10 C atoms are reacted with NH_3 at 850° to 1075° F in presence of Ni phosphate, Co chloride, or Co phosphate to produce nitriles.

U.S.P. 2,562,846 (3.5.48; 31.7.51). C. M. Reider and G. J. Pierotti, assrs to Shell Development Co. Dehydration of acrolein by azeotropic dist with ethyl ether.

U.S.P. 2,560,610 (26.11.43; 17.7.51). C. R. Wagner, assr to Phillips Petroleum Co. Thiophene or an alkyl thiophene having a replaceable H atom is reacted with an olefin at 400° to 700° F in presence of silica-alumina catalyst.

B.P. 655,475 (U.S. 28.6.47; 25.7.51). Standard Oil Development Co. Ethylene is contacted with a countercurrently flowing stream of a conc polybasic mineral acid, *e.g.*, H_2SO_4, the temp of the extract increasing continually in direction of increasing saturation.

B.P. 655,459 (27.1.48; 25.7.51). M. Buis, assr to N.V. de Bataafsche Petroleum Mij. Continuous sulphation of olefins by tangentially feeding olefins and sulphuric acid separately into a common mixing nozzle from which the mixture is tangentially discharged in finely divided form into an annular reaction chamber and finally neutralized.

B.P. 655,237 (U.S. 23.12.47; 11.7.51). E.I. du Pont de Nemours and Co. and W. F. Gresham. Glycol or glycerol or their esters are prepared by reacting CO and H_2 at >150° C and >1500 atm.

B.P. 655,210 (23.7.48; 11.7.51). Distillers Co. Ltd., D. J. Hadley, R. Heap, and R. J. Nichol. Preparation of acrolein and methacrolein by catalytic oxidation of propylene and *iso*butylene respectively with oxygen at 230° to 400° C, the reacting gases being passed in presence of Se over CuO on activated alumina.

B.P. 655,118 (29.4.48; 11.7.51). Distillers Co. Ltd. and E. G. E. Hawkins. Aliphatic diketones are prepared by reacting with an aqueous ferrous salt soln, a hydroperoxide of a saturated alicyclic hydrocarbon in which the peroxide group is attached to a tertiary carbon atom forming part of the alicyclic ring and which also bears an alkyl group, *e.g.*, methyl *cyclo*pentane hydroperoxide is converted to methyl butyl ketone.

B.P. 655,424 (Neth. 9.7.46; 18.7.51). Gevaert Photo-Producten N.V. Vinyl halides are produced by conducting acetylene and hydrogen halide in gaseous phase at 140° to 200° C over a solid catalyst containing $HgHal_2$ and $CuHal_2$ in weight ratio 1–50 : 1000.

B.P. 655,432 (U.S. 16.7.45; 18.7.51). A. W. Fairbairn, assr to N.V. de Bataafsche Petroleum Mij. Preparation of 1 : 3-dihalopropylenes and other polyhalogenated hydrocarbons, especially chloro compounds, by reacting 1 : 2-dihalopropane with free halogen at 300° to 800° C. V. P. P.

Coal, Shale, and Peat

2738. Sulphur in coal pyrolysis. W. Fuchs. *Brennstoff-Chemie*, 1951, **32** (17–18), 274–6.—In the pyrolysis of coal about 50% of the sulphur remains in the coke. Sulphur atoms probably replace carbon atoms in the graphite lattice, forming a very stable, undesirable structure. Equilibrium conditions in the carbon–sulphur system during coking are investigated with regard to hydrogen sulphide, carbon disulphide, mercaptans, and thioethers to ascertain the thermodynamic conditions, for reactions which give a max of gaseous sulphur compounds. Tabulated results are given for such reactions, also for possible reactions of sulphur compounds of iron and calcium which give rise to higher sulphur in the coke. Equations developed for the free energies of these reactions of sulphur and of sulphur compounds are summarized in tabulations. Changes in the equilibrium consts with temp are shown graphically. Mercaptans and thioethers are stable at low temps and can be formed from their elements. At higher temps only hydrogen sulphide and carbon disulphide are stable. Mercaptans and sulphides decompose into olefins and hydrogen sulphide. The final products are olefins, hydrogen sulphide, carbon disulphide, and carbon oxysulphide. Besides atomic hydrogen, carbon, and other elements give volatile sulphur compounds. A connected group of elements in the periodic classification which give rise to compounds volatile below 500° C, between 500° and 1000° C, and up to 1500° C is given. R. T.

2739. Oil-shale operations in New South Wales, Australia. A. J. Kraemer and H. M. Thorne. *U.S. Bur. Mines Rep. Invest. No.* 4796, July 1951.—An account is given of the equipment and operation at the National Oil Proprietary Ltd.'s refinery at Glen Davis, N.S.W., for mining and retorting oil shale and refining the crude product. Maps, plans, and photographs are shown of the Fell retorts and benches, the condensing plant, cracking and polymerization, and other refining units. The assay results of the oil shale by the N.O.P. Ltd.'s and Bur. Mines methods are given. The properties of the crude shale oil and the refined products are shown and discussed. Oil-shale and shale-oil research are surveyed. The success of the project has been hampered by high mining costs and the inability to mine sufficient material for continuous operation of retorts at full capacity. W. H. C.

2740. Gum formation in shale-oil naphtha. G. U. Dinneen and W. D. Bickel. *Industr. Engng Chem.*, 1951, **43** (7), 1604–7.—The formation of gum in several shale-oil naphthas

has been investigated. It is shown that oxidation produces rapid gum formation and is more important than light or heat in accelerating gum. The shale-oil gums contain 7 to 9% nitrogen, thus differing from gums formed from petroleum naphthas. F. M.

2741. Patents. Ger.P. 808,058, 26.4.51. (F. Winkler) Badische Anilin- and Soda-fabrik. Process for the gasification of granular, especially fine granular, tar-forming coals with a high ash content.

Fr.P. 969,408, 20.12.50. D. Horne, R. P. Marshalle, and H. F. Bondy, assrs to Low Temperature Carbonisation Ltd. Recovery of tar acids from oils and tar oils. *Brennstoff-Chemie*, 18.7.51, **32** (13–14). R. T.

Miscellaneous Products

2742. Aqueous dispersion of carbon blacks. E. M. Dannenberg and K. P. Seltzer. *Industr. Engng Chem.*, 1951, **43** (6), 1389–96.—The factors affecting the dispersion of carbon blacks in water, with and without the addition of dispersing agents, have been studied. It is shown that the initial bulk density of the black, the presence in the black of benzene extractable impurities, and the temp of the water all effect the degree of wetting. The amount of any given dispersing agent required to produce a suspension of a given solid content is related to the surface area, the presence of inorganic soluble ash contaminants, and the degree of surface oxidation of the black. These relationships are shown in graphical and tabular form. F. M.

2743. Lindane—a review of the background and development of this modern and versatile insecticide. G. S. Hensill. *Soap Sanitary Chem*, Sept. 1951, **27** (9), 135.—Lindane is the accepted commercial name for the gamma isomer of 1 : 2 : 3 : 4 : 5 : 6-hexachloro*cyclo*hexene, which is recovered from commercial benzene hexachloride (containing 12 to 14% gamma isomers) by a continuous process. The pure compound has a melting point of 112° C, a vapour pressure of 0·2 mm at 100° C, and is chemically unstable in the presence of strong alkalies. Its application as an insecticide depends upon the following properties: (*a*) The toxic properties are 5 to 10 times as great as D.D.T., and it has some residual properties (but less than some products): (*b*) It has wide versatility, controlling more species than any other insecticide. This is due to it acting in three ways—as a stomach poison, a contact poison, and a vapour-action poison: (*c*) With warm-blooded animals, it has a lower oral and dermal toxicity than D.D.T. and shows no build-up in the tissues.

The article reviews its applications, applied as a wettable powder, dust, emulsion, or liquid concentrate for control of pests in crops, animals, and the soil. N. W. G.

2744. Insecticidal aerosols. R. A. Fulton. *Soap Sanitary Chem*, Sept. 1951, **27** (9), 141.—The characteristics of liquefied gas aerosols flowing through small capillary tubing and orifices have been studied, particularly for application to the design of valves. To control the delivery to specifications (80% of the droplets less than 30μ), tables of particle dia distribution for various lengths of tubing, in relation to capillary dia, are shown, and recommendation made for a nozzle with an expansion chamber between two orifices with the dias in the ratio of 2 : 3. N. W. G.

2745. Bottle cleaning compounds. M. A. Lesser. *Soap Sanitary Chem*, Sept. 1951, **27** (9), 39.—The aim of this type of process is to make food containers, such as bottles, suitable for re-use—free from visible soil; free from invisible soil, such as bacteria, moulds, yeast, etc.; free from odour; free from alkali; and free from physical damage such as cracks, chips, etc. For handling large numbers special machinery is required, and these are of three types—hydro washers (with spray jets, etc.), soaker type, or combination methods. The washing compound used is stated to require the following properties: free-draining, no excessive foaming tendencies, good cleaning action, sufficient germicidal properties, and free rinsibility, with, in addition, no corrosion or excessive wear of the washing-machine and moving parts. The basis of all bottle-cleaners is an alkaline solution chosen to give a suitable combination of temperature, alkali strength, and time of soaking. The minimum is quoted as 3% caustic soda at

130° F with make-up added at a controlled rate decided by testing. Variations of formulæ are shown, including condensed phosphates and the increasing use in modern methods of synthetic detergents (at the rate of 3 lb per 100 lb of alkali). Additional compounds which can be used include anti-scuffing agents, to reduce defacements, and anti-foaming compounds. N. W. G.

2746. Detergents for textiles. S. M. Edelstein. *Soap Sanitary Chem*, Sept. 1951, **27** (9), 35.—Scouring of textile materials differs from laundry work in two important aspects—the nature of the soil (oily materials as against suspended dirt) and the need for flocculation (builders are needed for laundry detergency, but are of less importance for textile scouring). No general rule can be laid down for detergency requirements for textile scouring, since this will vary with different jobs, and subsequent processes, such as dyeing and finishing, may have to be considered. Article summarizes the chemistry of detergents according to the now well-accepted classification. Methods of evaluation are considered with particular reference to the textile problems. The sections covered in this article are chemical analysis, physical measurements (interfacial tension, etc.), wetting tests, launderometer tests with artificial soil, and small-scale laboratory textile scouring in an attempt to reproduce the actual plant conditions. (To be concluded.) N. W. G.

2747. Washability of waxed floors. R. B. Trusler. *Soap Sanitary Chem*, Sept. 1951, **27** (9), 49.—The problem tackled by the Chemical Specialties Manufacturers Assoc. was the washing of waxed asphalt-tile flooring, under conditions that (*a*) the dirt could be removed without damaging the wax film and (*b*) the wax could be removed without damaging the tile. The first is required for normal floor washing between polishing, and the latter to remove old films before a re-waxing job. It was found that asphalt tiles were unsuitable for laboratory evaluation, but reflectometry tests were carried out using linoleum tiles. The tests used eight commercial emulsified floor waxes, four detergent solutions (non-ionic, soap, soap plus T.S.P., soap plus pine oil), tested after each of three washes. Variation in the amount of wax removed was given, but gloss measurements were confused, since the rubbing action in the washing, in some cases, buffed the wax to an improved gloss. N. W. G.

2748. A short test to detect hydrocarbon adulteration of carnauba. L. Kresser. *Soap Sanitary Chem*, Sept. 1951, **27** (9), 139.—With the increased value of carnauba wax, more attention to adulteration is being paid. A quick qualitative method is suggested to indicate the presence of hydrocarbon waxes, hydrocarbon resins, and ester gum. The method is based on the ready solubility of carnauba wax and the poor solubility of hydrocarbon wax in hot *iso*propyl alcohol. A 10-g sample is boiled with 100 ml of *iso*propanol, decanted, and a further washing with 25 ml of *iso*propanol given. Hydrocarbon waxes are shown by an oily ring on the side of the beaker, resins and ester gum by precipitate on the bottom of the beaker. N. W. G.

2749. Patents. U.S.P. 2,560,916 (8.9.45; 17.7.51). P. S. Barnhart and J. C. Miller, assrs to Westfield River Plate Co. Inc. Cement for laminating sheets of paper, etc., comprising a microcrystalline wax m.p. >150° F, 23% rosin or modification thereof, 3% plasticizer, and 2% poly*iso*butylene, mol. wt. 75,000 to 200,000.

U.S.P. 2,560,773 (14.11.46; 17.7.51). S. P. Lovell, assr to Lovell Chemical Co. Carnauba wax substitute prepared by heating at *ca* 400° F, 7 to 35% molten polyethylene and 93 to 65% of a microcrystalline pet wax obtained by oxidizing pet tankage.

U.S.P. 2,560,439 (14.2.47; 10.7.51). J. A. Hannum, assr to Borg-Wagner Corp. Liquid explosive detonatable by means of a blasting cap consisting of 13 to 10 wt-% *n*-dodecane and 87 to 90 wt-% tetranitromethane and tetranitro-ethane.

U.S.P. 2,560,148 (8.2.49; 10.7.51). K. G. Arabian, assr to Shell Development Co. Wax emulsion containing a water-soluble aliphatic hydroxy polycarboxylic acid and its hexadecylamine salt.

B.P. 654,858 (3.8.48; 4.7.51). J. B. Storey, M. N. Strachan, and Monsanto Chemicals Ltd. Textile fibres are conditioned against slippage during spinning with an emulsion of colloidal silica and oil (vegetable, mineral, or sulphonated mineral oil). V. P. P.

CORROSION

2750. Corrosion and its control. M. E. Parker. *Oil Gas J.*, 20.9.51, **50** (20), 327; 27.9.51, **50** (21), 113; 4.10.51, **50** (22), 328; 11.10.51, **50** (23), 139.—Pt 28 of the series deals with bonding non-conductive pipe joints. It is essential that entire piping network forms an electrical unit.

Bonding is also essential to avoid any possibility of a spark over any bolted connexion in a pipe carrying inflammable products.

Pt 29 discusses interference effects in cathodic protection. One amp flowing from a steel surface to an electrolyte will cause dissolution of 20 lb metal per year, such a loss if concentrated in a very small area might have serious consequences.

Interference effects in cathodic protection can be largely avoided by proper placement of anodes or by bonding, and great care should be taken in design of complete piping, etc., system.

In Pt 30 criteria for cathodic protection are discussed, including break in current-potential curve, which indicates point at which protection is just barely established. Careful readings of current measurements in the central region of a system are among points included.

Potential of 0·85 V is a useful measure of protection.

Pt 31 concerns details of designing pipeline systems to minimize corrosion. These include use of insulated joints, casing supports, and bushings, adequate separation from crossing lines, installation of test leads, electrical continuity, and avoidance of unnecessary exposures. G. A. C.

2751. Protecting pipelines. Anon. *Petroleum*, Apr. 1951, **14** (4), 101–3.—Causes of corrosion and the methods used for the protection of pipelines are described. R. E. P.

2752. Metallizing—to prolong life of refinery equipment. J. E. Young, Jr. *Refiner*, 1951, **30** (7), 118–20.—The use and application of metallizing is discussed. In some cases it can give greatly improved service, giving surfaces more suitable than the parent metal. Any metal available in wire form can be employed, including various steels and alloys. R. W. G.

2753. Patents. U.S.P. 2,560,202 (24.7.48; 10.7.51). J. C. Zimmer, G. W. Duncan, and C. E. Paxton, assrs to Standard Oil Development Co. Rust-inhibiting composition consisting of a mineral lub. oil, 0·5 to 3% pentaerythritol mono-oleate, 0·5 to 3% oil-soluble sodium and/or calcium sulphonate and 0 to 1% degras.

U.S.P. 2,562,845 (12.12.47; 31.7.51). T. E. Reamer, assr to Shell Development Co. Anti-corrosion composition consisting of mineral oil and a C_{18-30} alkylated tetralin containing 1 to 3 metal sulphonate groups.

B.P. 654,434 (U.S. 11.6.47; 20.6.51). Standard Oil Development Co. Rust-preventive composition comprising mineral oil, a thio-ether substituted monobasic carboxylic acid of 2 to 6 C in the acid radical, *e.g.*, cetyl thioacetic acid, and an ester of a polyhydric alcohol. V. P. P.

ENGINES AND AUTOMOTIVE EQUIPMENT

2754. Diesel power replaces steam at California pumping station. D. H. Stormont. *Oil Gas J.*, 4.10.51, **50** (22), 199.—Union Oil Co. have installed three medium-speed diesel engines utilizing 16° gravity crude oil being pumped at their Antelope station, Calif. Automatic operation is a feature after starting up on manual control, the engines driving Wilson–Snyder quintuplex positive-displacement single-acting 5 × 8-inch pumps, each with a capacity of 540 brl/hr at 124 r.p.m. Station operation is described. G. A. C.

2755. The internal combustion compound engine. H. A. Jansen. *Ingenieur*, 28.9.51, **63** (39), W119.—On account of the superior economy of the piston-type engine as opposed to the gas turbine, it is considered that there may be a big future in the conversion of the kinetic energy in the exhaust gases into useful power by the use of

exhaust-gas turbines. The Wright "Turbo-Cyclone 18" employs three small turbines to boost up crankshaft power by about 20% without increase in fuel consumption. A number of diagrams and photographs are included. R. R.

Safety Precautions

2756. The possibilities of mercury poisoning in instruments shops. R. F. Angell. *Petrol. Engr*, 1951, **23** (2), C18.—The danger of exposed mercury is a serious one, but its effect can be minimized by good housekeeping, adequate ventilation, and personal cleanliness. Nine precautions to be observed, where mercury is used, provide a comprehensive code for eliminating chronic mercury poisoning, the symptoms of which are tabulated. E. K. J.

Miscellaneous

2757. Benzene from petroleum—How and how much. G. Egloff. *Refiner*, 1951, **30** (7), 127–9.—(*See* Abs. No. 2611.) R. W. G.

2758. The availability of LPG for direct motor fuel use. R. C. Alden. *Petrol. Process.*, 1950, **5** (11), 1180–6.—The case is presented for future large-scale developments in the liquefied petroleum gas industry. There appears to be every possibility that LPG will be used in large quantities as a direct motor fuel. Radial graphs are used to show the relative position since 1930 of natural gas and crude oil in cumulative U.S. petroleum discoveries, consumption, and reserves. Estimates are made for 1960. All show the economic desirability of making full use of natural gas and raising its market value. In determining the part LPG may be expected to play in the future a graphical analysis is made of the past motor fuel demand. From this it is concluded that LPG could take over a max of 45% of the market, probably succeeding primarily in the bus and truck market and in the tractor and other non-highway uses for gasoline. The supply potentialities indicate that a more realistic figure in the near future of 10 to 20% could be easily reached, an amount which would be needed to justify serious consideration of LPG as a motor fuel. It is expected that production could be raised to even higher levels in the longer-term future. D. W. F.

2759. Refinery expansion in England. V. S. Swaminathan. *Petrol. Engr*, 1951, **23** (1), C13.—The development of the refineries at Grangemouth and Llandarcy during three decades to their proposed annual capacities of 1½ and 2 to 3 million tons respectively is described in detail. E. K. J.

2760. Outstanding petrochemical plant. V. S. Swaminathan. *Petrol. Engr*, 1951, **23** (2), C5–8.—A detailed description of the Shell plant at Stanlow traces the two main processes based on the thermal cracking of gas oil under low pressure to give max yield of propylene and butylene. The former is processed to *iso*propyl alcohol, *iso*propyl ether, acetone, diacetone alcohol, and mesityl oxide, and the latter to secondary butyl alcohol and methyl ethyl ketone. Production of solvents is estimated at 20,000 to 24,000 tons from a feedstock of 100,000 tons of gas oil. E. K. J.

2761. Electrical engineering's contribution to oil. L. M. Goldsmith. *Oil Gas J.*, 27.9.51, **50** (21), 94.—A review of the role of the electrical engineering industry in the petroleum world over the past thirty-five years and predictions for the future are given.

Present consumption is 4·7 kWh/brl charged, total consumption in U.S. being 30,500,000 kWh/day. G. A. C.

2762. Radioisotopes. P. H. Emmett. *Oil Gas J.*, 27.9.51, **50** (21), 82.—Various and proposed uses for radioactive isotopes in the petroleum industry, including exploration, drilling, refining, distribution, testing, and in research are summarized.

Radio-isotopes are used in exploration and drilling as markers, in refining processes for measuring heights of products in tanks or reactors, in radioactive piston-rings in engine-wear tests, and as traces in various polymerization, isomerization, and cracking processes.

A list of forty-seven literature references is given. G. A. C.

BOOK REVIEWS

Principles of Geology. J. Gilluly, A. C. Waters, and A. O. Woodford. San Francisco, California: W. H. Freeman & Co., 1951. $5.75. £2 8*s*. 10½*d*. Pp. viii + 631.

The scope of physical geology is wide. It comprises phenomena taking place on the earth's surface and readily accessible for general observation, as well as other phenomena occurring at depth in the earth's crust, but whose existence can be inferred from the study of rocks at the surface and from other surface observations. It is a fruitful field for speculation, and one in which careful observation, experiment, and judicious physical and chemical reasoning can contribute much towards the solution of its problems.

"Principles of Geology," which is primarily a book on physical geology, omits some of the topics usually discussed under this heading, such as the development of river systems and the evolution of some topographical forms. However, the omissions, fully appreciated by the authors, are tolerable. The chapter headings give some indication of the deviation from the standard form: The earth's broad pattern; Gravity, isostasy, strength; Minerals; Rocks; Climates, weathering, and soils; Erosion; Geological maps, fossils, time; Movements of the earth's crust; Records of earth movement; Downslope movements of soil and rock; Stream erosion and deposition; Glaciers and glaciation; Ground water; Deserts; The oceans; Igneous activity; Earthquakes and the earth's interior; Mountains; Mineral resources. Throughout it is a welcome feature to find an approach which takes note of quantitative aspects and the correct application of the principles of physics and chemistry and of laboratory studies in association with field work.

Many of the topics discussed are introduced by a brief reference to the historical background of their study, while examples illustrative of various phenomena are drawn from many parts of the world. The structural examples are well chosen, and appropriate emphasis is placed on the relative nature of movements along faults.

At the end of each chapter is a collection of jottings concerning the chapter, and labelled "Facts, concepts, terms." The value of this feature is doubtful. Questions are appended to each chapter, and also a short list of "Suggested Readings." The "s" of "Readings" may be one of the literary eccentricities which escaped the "guinea pigs" of the authors' families on whom the material of this book was tried.

The typography is clear, and the slips few. Text figures vary widely in type, and are boldly drawn. Some of them are rather unconventional, verging on the symbolism beloved of those presenting certain forms of statistics for popular consumption as in illustrations in some government publications, but they are vivid.

"Principles of Geology" can be heartily recommended for its freshness, its readability, and for the authors' efforts to inculcate a sound approach to the study of physical geology. Its readers should not be geologists alone, and it deserves popularity such as has been attained by another book on physical geology, namely Professor Arthur Holmes' "Principles of Physical Geology." G. D. H.

Berechnung von Fraktionierkolonnen für Vielstoffgemische. Bruno Riediger. Berlin: Springer-Verlag, 1951. Pp. 88 + viii. DM 18.

A new method is outlined, based on the graphical solution of equilibria proposed by Hoffman, for investigating the behaviour of fractionating columns separating multi-component mixtures. The determination of bubble and dew points of multi-component mixtures and of all compositions of liquid and vapour in equilibrium between these points is facilitated by the use of modified vapour-pressure curves. These have a logarithmic pressure scale as ordinate and abscissæ representing different hydrocarbons. The parameter is the reciprocal temperature scale used for obtaining linear pressure–temperature relations for hydrocarbons.

The procedure for calculation of the equilibria of eleven component mixtures using the above principles is adequately described, and the subsequent application to the fractional distillation of this mixture shows the relative simplicity of the analysis. Comparisons of the calculated distillation curves with the familiar Engler and ASTM analyses are given showing the different characteristics of the method and emphasizing its realistic basis.

The final section of the book deals with the analysis of a column operating without side-streams. The calculation is carried out for both infinite and finite reflux ratios, with the necessary simplifying assumptions in the latter case, and compared with the analysis using key components.

An appendix of thirty-seven pages gives comprehensive tables of quantities necessary for carrying out an analysis by the method. The reader with little knowledge of German is assisted in the use of the tables by a short preface by the author in English. E. K. J.

The Fischer–Tropsch and Related Syntheses. (Including a Summary of Theoretical and Applied Contact Catalysis.) Henry H. Storch, Norma Golumbic, and Robert B. Anderson. New York: John Wiley and Sons, Inc., London: Chapman and Hall, Ltd. Pp. 610 + xii. 72s.

The American petroleum industry now considers that it will be many years before synthetic processes will be required to augment supplies of liquid fuels, and many of the companies, which a few years ago were spending large sums on research on the Fischer–Tropsch process, have suspended or seriously curtailed their work in this field. The U.S. Bureau of Mines, however, continues energetically to pursue its programme of work on the production of oil from shale and from coal. At the present time the work of the Bureau on the Fischer–Tropsch process, for example, is probably greater in amount and scope than that of any other organization in the world. During the past five years an increasing flow of publications dealing with both the scientific and technical aspects of the process has emanated from the Research and Development Branch of the Bureau's Office of Synthetic Liquid Fuels at Bruceton. It is fitting, therefore, that Dr Storch, Chief of the Bruceton station, together with two of his staff, should have undertaken the preparation of the first authoritative and critical text-book on the Fischer–Tropsch process.

Since 1945 the literature of the Fischer–Tropsch and related processes has been swollen to enormous proportions by the publication of innumerable C.I.O.S., B.I.O.S., and F.I.A.T. Reports resulting from the investigations of Allied teams in Germany, and by micro-film records of German documents obtained during these investigations. This has presented a formidable problem to those wishing to review existing knowledge in the field. One of the most valuable features of this book is that it includes a comprehensive and critical digest of this mass of German material which should obviate, in most cases, any reference back to the original.

The scope of the book is well described by the authors:—

> "Written primarily for chemists and chemical engineers engaged in Fischer–Tropsch or similar process development, this book presents the basic chemistry of the process, the results of catalyst testing and pilot-plant development work, and data on industrial operations. The first chapter describes the structure and reactivity of hydrogen, carbon monoxide, and the metals commonly used as catalysts, as well as the thermo-dynamics of reaction of these components. Chapter 2 presents an introduction to heterogeneous catalysis, the methods of studying catalysts and catalytic reactions, and a study of three reactions that are somewhat related to those of the Fischer–Tropsch synthesis. Chapter 3 contains a review of the development of catalysts for the synthesis. Here, catalyst composition and methods of preparation and pre-treatment are related to catalytic activity. Chapter 4 presents the laboratory and industrial development of the Ruhrchemie process, as well as more recent pilot-plant developments in Germany and in the United States. The different Fischer–Tropsch processes are classified according to the physical form of the catalyst and the method of removal of the heat of reaction. The productivity, relative efficiency, and versatility of the various processes are compared. This chapter concludes with a brief appraisal of the economic studies of the Fischer–Tropsch processes. Chapter 5 describes processes related to the Fischer–Tropsch synthesis, such as the oxo and *iso*paraffin syntheses. The last chapter relates activity and selectivity of catalysts to the variables of operation and to the phases present in the catalyst during use in the synthesis. The chapter concludes with a critical discussion of the mechanism of the synthesis."

From the point of view of the worker in the field and of the student of catalysis, the inclusion of basic chemical considerations in the first chapter and the review of heterogeneous catalysis in Chapter 2 add materially to the value of the book. These two chapters are admirably written. Even the specialist, however, will find the 200 pages of Chapter 3, dealing with catalyst development, rather tedious reading. Too much space has been devoted to the details of early work concerned with the preparation, reduction, and testing of nickel and cobalt catalysts which are no longer of technical interest. The summary at the end of this chapter is excellent, and contains sufficient information for the majority of readers.

For those primarily concerned with process development, Chapter 4 will be of major interest. Here again, rather too much space is taken up with detailed results of German pilot-plant operations with cobalt catalysts, and the preliminary section dealing with the general features of the process could have been expanded somewhat to give a more complete review of the characteristic effects of the process variables. In this chapter an attempt is made to assess the relative merits of the various process techniques, viz., fixed-bed, fluidized-bed, oil circulation, high-velocity gas recycle, etc. The authors judge the processes on the basis of the specific yield (yield of desired products per cu. m. of feed gas) and space–time yield obtained, and on "operability." A process is considered "operable" when it permits rapid attainment and prolonged maintenance of a steady state, *i.e.*, constant yield and quality of the product without interruption of the process or violent change in conditions. Thus, the Ruhrchemie fixed-bed process gives a steady state of 150 to 200 days, the Bureau of Mines oil-circulation process, one of 100 to 200 days, but for the fluidized-catalyst technique, the authors claim, the steady state is of only twenty days' duration. The authors conclude that the slurry process, despite its potential advantages, "has not yet been developed to an operable level."

In assessing the merits of the various processes, the authors were hampered by the absence of any authoritative published account of the fluidized-catalyst process as employed in the 8000 b.d. "Hydrocol" plant recently completed at Brownsville, Texas. They appear to have based their assessment of this process mainly on patent information, and unless their choice of such material was "inspired," they are likely to have been led astray. In the writer's opinion the operability of the fluidized-catalyst process is certainly greater than is suggested by the quoted steady-state of twenty days. In this process an infinite steady state is attainable by continuous replacement of catalyst at the rate necessary (of the order of 1 to 2 per cent per day) to maintain the reactor charge in a state of constant activity and fluidization properties (mean density and particle size).

When coal is the raw material for the process, the production of the synthesis gas is the major cost-controlling factor, and, as the authors point out, a high specific yield is therefore particularly desirable. From this standpoint the fluidized-process appears less attractive than other techniques.

The final chapter gives an excellent summary of present knowledge of the kinetics and reaction mechanism of the synthesis. The authors put forward a series of reactions as the basis of a proposed mechanism, but admit that the mechanism is still not clearly understood. Although their suggested mechanism might not be acceptable in detail to all workers in the field, it is based on the widely held belief that the main steps involve the formation and condensation of groups containing oxygen.

The book is excellently printed and bound, and contains very few errors. There is no doubt that it will remain the standard work on the subject for many years.

C. C. H.

ABSTRACTS AUTHOR INDEX

The figures refer to Abstract numbers

Abel, F. K., 1970
Abendroth, G. F., 907
Abraham, W. E. V., 529
Abrams, A. J., 170
Adams, E., 93, 582
Adams, J. D., 654
Adams, N. G., 1472, 1663, 2198
Adamson, J., 2388
Adelson, D. E., 1088, 2727
Adelstein, P. Z., 1036
Adkisson, J. F., 931
Ahlers, N. H. E., 760
Ahsmann, G., 669
AIME Prod. Review Committee, 2287
Aktiebolaget Svenska Aluminium Co. Sweden, 1703
Alberta Society of Petroleum Geologists, 1160
Albright, J. C., 1841
Alcock, J. F., 511
Alden, R. C., 1280, 2570, 2758
Alexanderson, E. L., 2098
Alfred, J. K., 495
Alkire, R. L., 2065
Alkyrie, R. L., 106
Allan, A. B., 723
Allen, C. M., 741
Allen, H. H., 2072
Allen, H. I., 1907
Allen, J. G., 1867, 2684
Allen, M. A., 1639
Allen, M. F., 614
Allen, T. O., 907
Allison, J., 327
Alpert, N., 2126–8
Alspaugh, M. L., 2576
Altpeter, J., 2727
Alty, H. J., 1085
Alvarez, M., 1174
American Assn Textile Chem., 234
Amick, E. H., 1449, 2129
Amidon, R. W., 1673
Ammott, E., 2407
Amner, J. W., 1306
Anderson, D. H., 220
Anderson, J., 1430
Anderson, J. L., 1155
Anderson, K., 2564
Anderson, L. E., 1623
Anderson, R. B., 1679–80
Anderson, T., 2096
Ando, H., 2723
Andrade, E. N. da C., 1061
André, R., 1563
Andres, D., 849
Andresen, H., 2233
Andreson, K. H., 567
Andrews, L. J., 1657–8
Angell, R. F., 2756
Annable, W. G., 162
Antzus, L. I., 1448
Appel, H. R., 1678
Arabian, K. G., 2749
Archer, F. G., 1105
Arend, A. G., 1525
Areshidze, K. I., 433
Aries, R. S., 275
Aristoff, E., 1668–9
Armitage, F., 1518
Armstrong, E. L., 1088
Armstrong, J. B., 1031, 1412
Armstrong, R. T., 407
Arnold, C. W., 1896
Arnold, G. B., 2141, 2153
Arnold, M. L., 180, 1632, 2643–4
Arnold, P. M., 1047
Arnold, R. T., 1673
Arnold, T. H., 2169
Arogan, H. J., 2565
Arthus, C. E., 1371
Arundale, E., 1432
Aschatz, F., 2350
Ashburn, H. V., 251
Ashforth, G. K., 722
Ashmore, P. G., 1458
Ashmore, S. A., 2566, 2707
Atkins, D. C., 2362
Audibert, E., 193
Austen, A. E. W., 1334
Austin, G. T., 285
Avery, I. F., 374
Ayers, W. J., 173
Ayres, E., 1962
Ayton, G. R., 2153

Babbitt, J. D., 629
Bachman, K. C., 1450
Bachman, W. S., 1764
Bachmann, W. S., 878
Baer, M. S., 1118
Baery, A., 636
Bagnold, R. A., 1415
Bailey, J. R., 1670
Bailie, J. C., 450
Baird, R. C., 130
Baird, T., 1384
Baker, D. R., 2667
Baker, W. E., 1837, 2438
Baldwin, T. A., 7
Ball, J. S., 217, 717, 1477, 2215
Ball, M. W., 1154
Ballande, H. M., 146
Ballard, S. A., 251, 1100
Ballet, J., 1569
Banes, F. W., 1432
Bankhead, C. C., 562
Banks, E. N., 1057
Banks, J. E., 293
Banks, W. H., 461
Banta, H. M., 2653
Barb, C. F., 1157
Barber, E. M., 721, 1926
Barber, R. C., 356, 1207
Barger, H. S., 929
Barker, C., 2431
Barker, G. E., 1967
Barker, K. R., 2140
Barker, M. G., 1477
Barkow, A. G., 2647
Barnes, F. C., 2053
Barnes, K. B., 1603, 2013, 2266, 2273
Barnet, W. I., 2216
Barnett, B., 1100
Barnett, R. S., 251
Barnhart, P. S., 2749
Barnwell, G. F., 2306
Barnwell, J. L., 1037
Barr, F. J., 2350
Barr, F. T., 2718
Barrett, J. P., 1107
Barrow, G., 1794
Barry, A. F., 352, 951
Barry, A. I., 2249
Bartholomew, F. J., 1885
Bartleson, J. D., 2147, 2727
Bartlett, J. H., 169, 2727
Bartley, J. H., 32
Barton, A. D., 1670
Barton, G. M., 640
Barton, P. D., 1426
Barton, R. C., 2411, 2727
Barwell, F. T., 1942, 1948
Bass, L., 1695
Bass, N. W., 1745
Bassinger, R., 870
Bastow, D., 1543
Batchford, W. P., 2164
Bates, C. W., 1891
Bates, W. F., 1183
Batuev, M. I., 430, 1451
Baugh, J. E., 956, 1615
Baum, J. S., 620
Baxter, A., 2641
Bayard, R. A., 148
Bayley, C. H., 1148
Bazhulin, P. A., 1266
Beal, C., 1600
Beam, J., 2543
Bean, H. S., 2354
Beard, J. H., 2418, 2554
Bearse, A. E., 2608
Beaven, E. W. J., 1320
Beaven, G. H., 1268
Bechtold, I. C., 130
Beck, A. F., 64
Beck, T. R., 2549
Becker, D. L., 1384
Becker, F., 1452
Beerbower, A., 1088
Beeson, C. M., 903–6, 1378
Beeson, H. H., 1734
Bekkedahl, N., 1462
Belknap, M. A., 243, 1269
Bell, A. H., 1210, 2056
Bell, E. A., 50
Bell, F., 681
Bell, J. S., 586, 1781
Bell, M. F., 222
Bellam, D. J., 2695
Below, F., 1737, 2251
Benedek, P., 720
Benedict, W. S., 2370
Benitez, M. P., 2386
Benner, F. C., 151, 2193
Benson, T. S., 2690
Bentz, A., 1215
Berg, G. R., 2252
Berg, L., 1238, 2529
Bergman, W. E., 69
Bergmann, E., 1653, 1662
Bergmann, F., 1653, 1662
Bergstrom, R. F., 2411, 2727
Berlin, E. W., 2479
Bermingham, J. A., 1384
Bernard, G. G., 933
Bernard, R. A., 638
Bernstein, H. J., 1095
Bernstein, R. B., 1070
Berry, E. W., 812, 2480
Berti, V., 1491, 2330
Berton, A., 2568
Bessey, G. E., 488
Best, W. C., 579
Bestougeff, M., 2204
Bickel, W. D., 2740
Biedendieck, C. H., 1785
Bielak E. B., 1939
Bieler, W., 1484, 2710
Bielstein, W. J., 1186
Billue, G. H., 1634
Bilosoly, J. P., 177
Bilton, N. F., 1951
Binckley, C. W., 1790
Biribaur, F. A., 169
Birks, L. S., 448
Birnbaum, A., 1457
Bishop, E. T., 1432
Bittmar, R., 138
Black, C. R., 2520
Blade, O. C., 728–9, 1273, 2719
Blaedel, W. J., 1069
Blair, C. M., 1718
Blair, G. W. Scott, 670
Blair, P. M., 2046

Blake, J. W., 1123
Bland, W. F., 798
Bliss, J. E., 1368
Bloch, H. S., 1039, 1519
Blohm, C. L., 1080
Blok, H., 2722
Blott, J. F. T., 1306
Blue, R. W., 2166
Blumer, A. F., 283, 1149
Boberg, I. E., 1816
Bobrowski, F. P., 2043
Boddy, J. H., 1282
Boedeker, E. R., 1677
Boelhouwer, J. W. M., 437
Bolam, T. R., 1319
Boman, D. S., 772
Bond, D. C., 266
Bond, R. K., 1624
Bondhus, F. J., 1100
Bondi, A., 475, 1311, 1497
Bondy, H. F., 2350, 2741
Boner, C. J., 2405
Bonilla, C. F., 1411
Bonnard, E. G., 48
Bonner, R. F., 2154
Bonnington, S. T., 2511
Boon, E. F., 2522–3
Booser, E. R., 440
Booth, B. E., 15
Borden, G., 1787
Bosinelli, G., 1488
Bottiglia, T., 2330
Bouchier, F. G., 70
Boué, J., 2512
Bouillot, J., 2568
Bourns, A. N., 1919
Bowers, E. F., 1777
Bowers, N., 883
Bowles, V. O., 2685
Bowman, J. R., 1419, 2124
Box, W. T., 961
Boyd, J., 954, 1520, 1562
Boyd, T. A., 1275
Boyd, W. L., 577
Bradbury, E. J., 1983
Bradfield, H. H., 2076
Bradford, B. W., 1251
Braid, P. E., 1908
Brain, R. C., 1054
Bramer, H. C., 2510
Brancker, A. V., 602, 745, 2368, 2700
Brandenberg, W., 1671
Brandon, R. C., 2685, 2690
Brann, W. G., 181
Bratzler, K., 2537
Braun, —, 1882
Brechenfield, R. R., 1235
Breitenback, J. W., 642
Breston, J. N., 565, 917, 1101, 1196
Breuil, J., 1633, 2328
Briggs, F., 552, 862
Bright, G. S., 474
Brillouin, L., 2170–1
Brilton, N. F., 691
Brimley, K. J., 1966
Brink, J. C., 673
Brinkman, H. C., 668
British Thomson-Houston Co. Ltd. (London), 242
Broadbent, R., 2391
Broeze, J. J., 1544
Brook, A. G., 1059
Brooke, H., 2666
Brooks, E. J., 448
Brooks, J. W., 2727
Broom, W. E. J., 472
Brooner, G. M., 1648, 1873
Brown, B. W., 900
Brown, G. L., 2430
Brown, H. W., 2275
Brown, R., 869
Brown, R. A., 1473
Brown, W. M., 1997
Brownell, L. E., 1838
Browning, J., 361
Browning, W. S., 361
Brownscombe, E. R., 1200
Bruce, G. H., 2472
Bruce, W. N., 1958
Bruckner, G., 657
Brüggeman, F., 1760
Bruijsten, J., 2321
Brummage, K. G., 385
Bruner, F. H., 177
Brunswig, H., 1130
Bryjak, E., 2036
Bubb, F. W., 695
Buchan, R. C., 2624, 1015, 2624
Buchanan, N. N., 1096
Buchmann, F. J., 1150, 2350, 2694
Buck, R. L., 2314
Buckley, D. J., 1524
Buckley, P. S., 1738
Buford, T. B., 1181
Buis, M., 2737
Bukowiecki, A., 2440
Burdine, N. T., 355
Buret, 1517
Burgard, A., 2350, 2694
Burman, L. M., 1105
Burnett, E. S., 399
Burstin, H., 244
Burwell, J. T., 785
Busche, R. M., 2705
Bush, R. E., 66
Butenuth, G., 2674
Buthod, P., 2517–18
Buzagh, A., 664, 676
Byron, E. S., 2125

Cabot, L. W., 1314
Calcote, H. F., 228, 2575
Calhoun, J. C., 572
Calingaert, C., 449, 1655
Calkins, A. E., 1088
Callaway, F. H., 944
Cambron, A., 195, 2737
Camin, D. L., 663
Camp, A. C., 1651
Campise, N. O., 2624
Canan, T. C., 78a, 915
Canjar, L. N., 2185
Cannon, G. E., 1186
Cannon, W. A., 223
Canright, R. B., 1283
Cantrell, T. L., 1088, 2721
Carlson, A. E., 2584
Carlson, C. S., 169
Carlson, F. T., 2253
Carlson, M. T., 231
Carlson, R. F., 40, 394, 554, 557, 829, 833, 1758, 2017
Carlson, R. H., 832
Carpenter, H. C., 1238
Carr, C., 2178
Carr, W., 257
Carroll, F. E., 1289
Carroll, W. C., 1874
Carter, N. D., 2141
Case, L. C., 1331
Cashman, A. F., 1507
Cashman, E. P., 1507
Casper, J. C., 867
Caswell, C. A., 26
Cattell, R. A., 1916
Cawley, C. M., 2458
Chajec, W., 1529
Chamberz, A., 2477
Chaney, P. E., 943
Chanter, E. E., 1556
Chantler, H. M. D., 2197
Chapin, W. F., 1080
Chapman, A. H., 2479
Chapman, F., 2735
Charrin, V 1694
Charriou, A., 268
Chase, J. L., 895
Chasteen, L. W., 1798
Chauviere, A. C., 105
Cheney, H. A., 1430
Chenleek, J. P., 2201
Chermin, H. A. G., 183
Chesters, J. H., 2319
Chilton, C. N., 2609
Christianson, E. G., 19
Christie, D. F., 2033
Christopher, R. G., 2120
Christopherson, D. G., 1932
Chu, J. C., 1236, 2705
Chu, T. Y., 750
Cibula, G., 755
Cichelli, M. T., 1419
Cipriano, L. D., 2356
Claes, A. J., 1227
Clark, E. L., 2142
Clark, G. H., 472
Clark, K., 1352
Clark, K. A., 1353, 2728
Clark, R. C., 766
Clark, R. H., 640
Clark, R. O., 1072
Clarke, E. W., 2690
Clason, C. E., 892
Claudet, A. P., 71
Clausen, T. I., 1507
Clay, J. A., 494
Clayton, D., 1935, 1937
Clayton, N., 855, 1591
Cleaveland, D. M., 746
Clerc, R. J., 211
Cohen, M., 1318
Colburn, A. P., 2533
Cole, J. A., 1300
Cole, J. P., 241
Coleman, H. J., 1663
Colema.., R. J., 2206
Collier, L. D., 2052
Collins, C. P., 1185
Collins, F., 1200
Compere, E. L., 2552
Con, A. L., 1242
Conison, J., 2557
Connor, J. P., 402, 1866, 2681
Conolly, J. M., 698
Conrad, A. L., 1067
Cook, A. B., 2043
Cook, F. V., 520
Cook, J. C., 952
Cook, J. E. E., 2250
Cook, N. C., 1666
Cooke, F. V., 1340
Coomber, S. E., 345
Cooper, C. M., 153
Couper, R. C., 2056
Cooper, W. T., 1685
Cope, A. C., 1659–61
Copsulsky, W., 275
Cordero, F., 2392
Cordes, H., 1654
Cornell, P. W., 2690
Coull, J., 1253, 1419, 2101, 2124
Coulter, J. B., 1381
Coumbe, A. T., 374
Coupard, C. J. C. D. F., 2727
Courtney, R. P., 911
Cox, B. B., 1602
Cox, J. T., 176, 245
Cox, R. J., 2216
Cozzens, F. R., 564, 946, 962, 1598
Crandall, F. B., 602
Crandell, D. R., 537
Crantz, R., 1702
Crawford, R. V., 2431
Craze, R. C., 1201
Crick, R. G. D., 2422
Crippen, E. G., 2195
Cristol, S. J., 1674
Croft-White, P. G., 1320
Crooker, J. F., 1096
Crooks, R. C., 1256
Crookshank, H., 1178
Crosby, W. L., 117
Crothers, J. M., 522, 652
Crouch, J. O., 901
Crouch, W. W., 177
Crowe, T. A., 2234
Crowell, J. H., 2691

Croxton, F. C., 2203
Cruickshank, A. J. B., 630
Crutchfield, J. W., 1777
Csokan, P., 743
Culberson, O. L., 1379
Curfman, L. W., 377
Curran, B. E., 885
Currie, C. C., 1500, 1505, 1608
Curry, W. J., 1533
Cyphers, E. B., 2727
Czastka, J., 278
Czernikowski, J., 53, 2007, 2459

Dacey, J. R., 1099
Dahl, L. A., 674
Dale, C. B., 945
Dale, R. H., 1558
Dallenbach, F., 1345
Daly, J., 853
Daly, J. B., 1238
Damick, A. D., 2142
Danckwerts, P. V., 2675
Dancy, T. E., 484–5
Danforth, J. D., 158
Daniels, L. S., 412, 1880
Danielsen, H. H., 2051
Dannenberg, E. M., 2742
Danner, A. V., 410
D'Arcy, N. A., 873
Darley, R., 1088
Darling, S. M., 2145, 2147
Darney, M. J., 604
Dart, J. C., 2153
Darwert, B. De B., 188
Darwin, Sir C., 2254
Daudel, R., 428
Dauwalder, —, 1817
Davey, W., 249–50, 1310, 1480
Davidsohn, A., 2597
Davidson, D. C., 162
Davidson, D. D., 1081
Davies, E. B., 2517
Davies, J. A., 393
Davies, J. T., 1261
Davis, G. M., 2195
Davis, K. A., 741
Davis, R. F., 1281
Davis, S. G., 1859
Davis, W. B., 1776
Dawson, I. M., 2175
Dawson, J. G., 1943
Dawson, J. H., 1010
Dawson, R. D., 74
Dawtry, S., 1306
Day, R. W., 2550
De Armond, P., 547, 827, 981
De Coudier, J., 528
De Forest, E. M., 1824
De Lany, W. H., 624
De Ong, E. R., 1704
De Waele, A., 1690
De Wilde, H., 2236
De Witt, S. N., 1374
Dean, G. F., 1794
Dean, H. M., 435
Deanesly, R. M., 401
Decker, G. C., 1958
Decker, W. H., 613, 2519
Deckers, W., 2585
Deegan, C. J., 24, 29, 30, 37, 63, 109, 314
Deely, C., 394
Degler, H. E., 2525
Deibner, L., 1881
Deitz, V. R., 2389
Delaney, W. E., 450
Delbourg, M. P., 427
Delbourgo, R., 2167
Denekas, M. O., 2253
Denham, R. L., 1746
Dennis, E. W., 1712
Dennis, T. W., 1077
Denton, W. I., 2737
Denzler, H. E., 1003
Derksen, J. C., 2732
Desjardins, L., 532
Desty, D. H., 2118
Deters, J. F., 2189
Devol, L. T., 173
Dewess, R. J., 1784
Diamond, W., 361
D'Iannie, J. D., 2211
Dibeler, V. H., 1058, 2371, 2392
Dickey, C. A., 1838
Diehl, C. H., 1853
Dietz, R. S., 2613
Dinardo, A., 151, 2193
Dineen, G. U., 217, 219, 2740
Djingheuzian, L. E., 1952
Dodd, C., 1061
Dodd, C. G., 2253
Dodson, R. M., 1673
Doelter, G., 2200
Doherty, H. G., 1431
Dolez, R., 390
Doll, H. G., 67, 342
Dombrowski, H. S., 1838
Donahue, R. W., 1922
Donath, E., 2350, 2694
Donnell, J. W., 153, 626
Donnely, R. P., 2391
Doody, T. C., 2108
Doremus, E. P., 263
Doremus, G. L., 263
Dornfield, E. G., 1912
Dorreen, J. M., 2467
Doscher, T. M., 2362
Doty, E. C., 353
Dougherty, J. F., 1801–2
Downs, G. R., 1745
Doyle, P. J., 251
Draeger, A. A., 2542
Drake, H. L., 594
Draper, R. G., 2197
Dresser, H. A., 1836
Drinkwater, J. W., 1009
Drumheller, J. V., 368
Dryden, I. G. C., 480–1
Drysdale, R. F., 1542
Duckworth, J. B., 1923
Duff, D. M., 59, 88, 90, 91, 589, 593, 795, 797, 836, 975–8, 1606, 2091, 2470, 2625
Dugger, C. L., 1684
Dugleux, P., 190–2
Dummett, A., 2113, 2528
Duncan, G. W., 2753
Dunkle, H. H., 140, 1140
Dunlop, H. F., 2280
Dunn, C. L., 1424
Dunn, E. B., 1397
Durand, E. J., 723
Duriński, A. M., 2104
Duval, C. A., 1809
Duwez, P., 2165

Eagle, C. J., 2166
Earlougher, R. C., 916
Eastham, A. M., 224
Eatwell, H. J., 2441
Ebrey, G. O., 1292
Eby, L. T., 2123
Eccleston, B. H., 1663
Echterhoff, J. H., 2315
Eckard, W. E., 1786
Eckhardt, E. A., 61
Eddy, G. E., 1795
Edelstein, S. M., 2746
Edgar, J. A., 725
Edgar, T. L., 2349
Edghill, C. M., 576
Edinger, W. M., 1384
Ednunster, J. W., 1314
Effinger, R. T., 1980–1
Egerton, A., 1277
Egloff, G., 416, 1565, 2090, 2135, 2611, 2757
Eichelmann, J. F., 2607, 2642
Eidus, Y. T., 424, 431, 1451, 2360
Eilar, K. R., 1674
Eilerts, C. K., 1105
Eiseman, B. J., 1961
Ekholm, E. L., 2350, 2694
Ellenberger, A. B., 569
Elliot, M. A., 1281
Elliott, W. D., 967
Ellis, C. F., 2219
Ellis, F. W., 531
Elston, J., 185
Eltenton, G. C., 186
Eltham, B. E., 471
Elven, E. V., 1097
Elving, P. J., 198, 2126–8
Emeléus, H. J., 688
Emmett, P. H., 2762
Emmrich, F., 1557
Endersby, V. A., 711–12
Endres, H. A., 2206
Engelhardt, F., 649, 1884, 2571
Engleman, R., 2066
Englund, S. W., 2120–1
Enquist, M. A., 1541
Erdman, O. A., 1584
Erskine, J., 2221
Eschmann, P., 2404
Espach, R. H., 2274, 2476
Estcourt, V. F., 1843
Evans, A., 1063, 1089
Evans, B. W., 586
Evans, D. L., 964
Evans, R. F., 1444
Evans, R. G., 659
Evans, R. L., 925
Evans, T. H., 1919
Evans, T. W., 1100
Evans, U. R., 765
Evans, W. R., 2473
Everett, J. P., 572
Eveson, G. F., 1062
Ewing, S. P., 1984

Fagg, L. W., 83
Fagin, K. M., 367, 858, 969, 984
Fairbairn, A. W., 2737
Falcon, N. L., 2272
Fanestiel, A., 1024
Faris, R. B., 172, 2147
Farley, R. C., 864
Farrar, G. L., 2563
Farrell, D. M., 272
Fawcett, F. S., 1660
Fawcett, J. R., 1716
Fay, R. W., 762
Fazekas, G. A. G., 2001
Feeley, F. J., 633
Feilden, G. B. R., 1728
Feldman, J., 2673
Feldman, K. T., 490
Felt, A. E., 1929
Fenn, J. B., 2605
Fenn, L. G., 941
Fenske, M. R., 181, 440
Ferrier, J., 2512
Ferris, B. J., 288–9
Ferry, J. W., 936
Fetterly, L. C., 2153, 2334, 2690
Fettke, C. R., 1385, 2067
Fidler, F. A., 2118
Fiedler, H. P., 2727
Field, J. H., 85
Finch, G. I., 1933, 1938
Finch, H. de V., 1100
Fink, D. F., 209, 218
Finn, W. J., 2170
Fischer, P. W., 556
Fisher, C. H., 2164
Fisher, G. S., 2177
Fisher, H. 9., 69
Fisher, J. C., 2157
Fitch, A. A., 2033
Fleming, C. L., 1293
Fleszar, B., 2242, 2460
Fletcher, C. D., 1189, 1370
Flickinger, C. H., 251
Flom, D. G., 2127
Florin, F., 2669
Floyd, C. M., 1437
Folda, B., 251
Foran, M. R., 1859
Foret, E. L., 1244

Fork, C. H., 1844
Fort Worth Geological Society, 1164
Forziati, A. F., 663
Foster, A. L., 2682
Fothergill, C. A., 1735
Fountain, E. B., 1430
Fowler, F. C., 2670
Fowler, W. H., 580
Fox, F. G., 1580
Fox, H. W., 1456
Franck, H., 2732
Franck, H. G., 2531
Franke, H., 2316
Frankenburg, W. G., 117
Franklin, L. O., 2689
Franklin, W. H., 2310
Frascati, F. P., 2141
Frasch, J., 491
Frederick, E. H., 782
Free, G., 2153, 2341, 2415, 2685, 2716
Freeman, L. B., 805
Freidlin, L. K., 1446, 2359
Freling, E., 189, 191
Freund, M., 661
Freymark, H. U., 1218
Friedman, H., 448
Friedman, L. D., 1521
Friedman, S., 2692–3
Friedman, W., 1257, 2367
Fritz, J. S., 226
Fritz, W., 2384
Frolich, P. K., 1432
Frost, E. M., 346, 2044
Fruechtenicht, H. L., 1818
Fry, F. E. J., 2248
Fry, J., 2274, 2476
Fuchs, O. A., 161, 2540
Fuchs, W., 2738
Fuller, J. S., 940
Fulton, R. A., 2509, 2744
Fulton, W. F., 1429
Furby, N. W., 229
Furth, M. A., 1979
Fussman, F., 624

Gagnon, P. C., 195
Gahus, J., 1848
Galat, A., 1671
Gallop, W. B., 1581
Galloway, J. O., 110, 2086
Galstaun, L. S., 1252
Ganger, D. R., 1347
Gardiner, J. B., 2690
Gardiner, J. F., 1204
Gardner, F. T., 567
Garmon, R. C., 2605
Garner, F. H., 525, 722, 1254, 1355, 2402
Garnhausen, W. J., 1509
Gartner, A. J., 2663
Gasson, E. J., 678
Gaudry, H., 426
Gawlinski, M., 1763, 1767, 2471
Gay, E. J., 1923
Gay, P. J., 1971
Geddes, B. W., 1293
Gee, K. W., 2674
Geffen, T. M., 2478
Geiger, F. G., 381
Gemant, A., 677, 2098
Geniesse, J. C., 1494
George, C., 1109
George, J., 1687–8
Gerster, J. A., 2533
Geschelin, J., 1994
Geschwind, O., 1862
Getty, R., 685
Geyer, B. P., 1100
Ghosh, J. C., 1445
Gianoli, E., 2712
Gibbon, A., 768, 876, 928, 1009, 1626, 1770
Gibson, H. J., 725
Gibson, J. D., 1502
Giedroyc, V., 484–5
Gilbert, W. I., 2690
Gillet, A., 1522
Gillette, L., 1313, 1515
Gillham, R. C., 641
Gilmer, R. B., 2575
Gilmore, E. H., 199
Gilmore, F. E., 2570
Gilmore, R. B., 2479
Giraitis, A. P., 160
Giraud, A., 1913
Girelli, A., 2163, 2713
Girzejowski, —, 2569
Gishler, P. E., 636, 2668
Gislon, A., 2694
Giuntini, L., 1528
Givens, H. C., 1335, 1833, 1892
Glaser, R., 1436
Glasgow, A. R., 2374
Glass, E. M., 1286, 2406
Glavis, F. J., 1495
Gleason, A. H., 1039
Glenn, A. H., 1595
Glenn, W. E., 953
Glogoezowski, J. J., 230
Goalby, B. B., 659
Godsave, G. A. E., 1278
Goebel, L. A., 6
Goebel, M., 2571
Goldberg, B., 1537
Goldberg, M., 487
Goldblatt, L. A., 2177
Goldenberg, S. A., 2320
Golding, B., 2601
Goldman, M., 2185
Goldsmith, L. M., 2761
Goldsworth, E. C., 518
Goles, C. H., 693
Gollum, K. W., 2571
Gooch, F. W., 572
Good, G. M., 1433
Goodger, A. H., 2323
Goodman, A. J., 1586
Goodman, I. A., 1664
Goodridge, B. E., 1334
Goodwin, C. L., 492
Gordon, B. E., 225
Gorka, H., 1570, 2041
Göttner, G. H., 1060
Gouch, F. W., 966
Gould, J. P., 974
Gourney, L. S., 355
Govare, J. P., 1359
Grabiel, C. E., 2119
Grace, E. J., 144, 1889, 2696
Grace, N. H., 1037
Graeser, H. J., 1104
Graf, D. L., 538
Grafton, R. W., 716
Grandey, L. F., 631
Granlund, J. T., 640
Granquist, W. T., 1422
Grant, G., 1698
Grant, G. A., 1902
Grant, R. P., 1795
Gravath, A. M., 475
Gray, J. B., 2194
Gray, P., 732
Gray, S. G., 1746
Gray, V. R., 235
Grebe, H. A., 1641
Greco, E. C., 1093
Green, F., 1105
Green, F. R. G., 2346, 2690
Green, L., 2165
Green, T. H., 307
Greene, F. C., 363
Greenhalgh, G. H., 2425
Greenshields, R. J., 725
Greer, W. J., 1597
Gregory, L. S., 392
Gregory, V. P., 566, 935
Grekoff, N., 1752
Gresham, W. F., 2737
Greville-Smith, C., 753
Greybeal, O. A., 2290
Griffiths, E., 1686
Griffiths, J. C., 1780
Grim, R. E., 1572
Grimaldi, J. V., 789
Grodzinski, P., 1947
Groff, J., 1493
Groninger, C. R., 566, 935
Gross, L., 1832
Grossman, W., 891
Grote, H. W., 2139
Grove, C. S., 2194, 2535
Gründer, W., 1769
Gryc, G., 1171
Guénoche, H., 425
Guenter, E. A., 886
Guillemin, A., 1913
Gulbransen, E. A., 2168
Gundel, W., 2585
Gundermann, E., 2207
Gunn, E. L., 231
Gunter, H., 584
Güseva, I. V., 431
Guthrie, B., 2217
Gutmacher, R. G., 237
Guyot, R., 444
Guzman, E. J., 2060
Gwin, G. T., 2542

Haak, F. A., 2394
Hadden, N., 208
Hader, R. N., 1245
Hadley, D. F., 2737
Haendel, H., 2350, 2694
Haensel, V., 2339
Haertsh, N., 630
Hafford, J. A., 2046
Hagen, H. B., 70
Hager, D., 23
Hager, K. F., 264
Hahn, O., 2329
Hahn, R. B., 459
Haigh, B. R., 32
Haines, R. L., 1902
Hakala, N. V., 1293
Halbouty, M. T., 2621
Halder, R., 1903
Hale, J. H., 1477
Hall, A. M., 2653
Hall, C. C., 413
Hall, M. E., 221
Hall, W. K., 1679–80
Halpern, C., 441
Halpern, J., 1038
Halpern, M., 400
Halton, G. R., 2310
Ham, A. J., 1071
Hammerich, T., 1485
Hammond, P. R., 1392
Hamnond, R., 370, 998, 2646
Hammond, R. E., 1984
Hamontre, H. C., 1105
Hampp, W., 2410
Handlos, A. E., 1420
Hangs, F. G., 2638
Hanmer, R. S., 2689
Hannan, R. B., 207
Hannum, J. A., 2749
Hansen, K. A., 452, 458
Harbert, W. D., 623
Harbin, G. C., 2621
Hardy, A. C., 551, 2094
Harlan, J. L., 255
Harlton, B. H., 1750
Harman, D., 2727
Harman, H. M., 1309
Harnsberger, A. E., 1847
Harper, G. M., 1106
Harrell, J. B., 366
Harris, B. L., 2132
Harris, C. C., 455
Harris, E. H., 2164
Harris, J. C., 1968, 2427
Harrison, H. C., 1975
Harrison, J. M., 2674
Harrison, R. H., 2562
Hart, W. B., 620
Harvalik, Z. V., 210
Harvey, C. C., 1113
Harwood, J. J., 265

Haskett, I., 1778
Hassebroek, W. E., 1779
Hassmann, H., 2246
Haszeldine, R. N., 1260
Hatch, L. F., 1100
Hawkins, E. G. E., 678–80, 2737
Hawkins, J. E., 856
Hawthorne, R. R., 2280
Haxo, H. E., 1483
Hays, M., 2075
Hazlett, F. P., 207
Heap, R., 2737
Hebard, G. G., 359
Hedberg, H. D., 2304
Hedene, E. E., 884
Hedlin, J. P., 133
Heiks, R. E., 2203
Heiligmann, R. G., 1514
Heimberge, W., 2718
Heiss, J. F., 2101, 2510
Hellums, E. C., 871
Helmers, C. J., 1047
Hemminger, C. E., 2153, 2694
Henderson, J. H., 80
Henderson, N., 640
Hendon, L., 1245
Hendricks, H. L., 1911
Hendrickson, J. W., 2068
Hensill, G. S., 2743
Henstez, 2553
Hepp, H. J., 2685
Hepworth, J. L., 1337
Herbert, W., 2694
Herbst, J. H. E., 1048
Hermann, E. C., 1661
Hermes, L. M., 68
Hermonat, W. A., 1483
Heron, S. D., 1929
Herrington, L. P., 1466
Herschman, W. L., 42
Hersh, R. E., 440
Hervey, O. S., 15
Hess, H. V., 2153
Hess, L. D., 2211
Hessin, W. A., 1197, 1202
Hiatt, G. D., 2155, 2155a
Hibbard, R. R., 1063
Hickinbottom, W. J., 2361
Hickman, K., 2173
Hickman, K. C. D., 2116
Hicks, T. G., 391, 610, 859, 1023, 1122, 1835, 2103, 2661
Higgins, H. G., 682
Hilderbrandt, A. B., 70
Hilditch, T. P., 2431
Hilfiger, J. P., 2711
Hill, A. G., 2679
Hill, A. M., 1004
Hill, L. R., 2317
Hindin, S. G., 1656
Hines, E., 2098
Hines, L. E., 937–9
Hinshelwood, C., 182
Hipple, J. A., 286
Hirschler, A. E., 1424
Hirshberg, Y., 1653, 1662
Hitchcock, J. H., 1301
Hixon, W. L., 1790
Hochgeesang, F. P., 447
Hodgkins, J. W., 1099
Hodsman, G. F., 803
Hoekstra, J., 2139
Hoell, G. S., 1992
Hoeppel, R. W., 2039
Hoertz, N., 1339
Hoiberg, A. J., 2733
Holaday, W. M., 282, 524
Hölbel, H., 2571
Holden, F. T., 2070
Holder, C. H., 1047
Holler, H. D., 764, 1536
Hollister, K. L., 734, 1294
Holt, W. W., 604
Hölzl, A., 2571
Hommel, M. C., 1505
Honig, R. R., 1065
Hoog, H., 1248, 1258
Hoot, C. F., 40, 829
Hoover, L., 1749
Hopkins, O. B., 989
Hopkins, R. L., 2677
Hopkins, W. B., 578
Hopper, P., 2721
Horn, A. J., 1594
Horne, D., 2350, 2741
Horne, J. W., 2215
Horne, W. A., 1496, 2690
Horner, W. L., 81, 2475
Hougen, O. A., 423
Hough, E. W., 442, 2278
Hough, L. W., 105
Houston Geological Society, 1163
Howard, F. L., 2390
Howard, K. C., 2309
Howard, R. A., 82, 1375
Howard, R. E., 2102
Howell, R. P., 1624
Howell, W. E., 78
Hower, W. F., 968, 971
Howlett, J., 2449
Hoxeng, R. B., 259
Hoylman, H. W., 854
Hubbard, A. B., 758, 2592
Huber, T. A., 907
Hubley, C. E., 1898
Hubmann, O., 2534
Hudson, B. E., 1424
Hughes, C. L., 1978
Hughes, E. C., 172, 2145, 2147, 2688, 2727
Hughes, H. K., 447
Hughes, J. C., 1920
Hughes, R. V., 945
Hugues, F., 2421
Huitt, J. L., 2117, 2530
Hulf, H. J., 2441
Hull, D. E., 379
Hull, W. G., 2217
Hulsberg, H. A., 286
Humble, L. V., 772
Hume, G. S., 2717
Humphreys, H. S., 1084
Hundere, A., 498
Hunt, J. M., 1077
Hunt, K. C., 1287–8, 2400
Hunter, C. D., 361
Hunter, T. G., 630
Hunter, W. H., 681
Huntingdon, R. L., 2117, 2530
Hurter, H., 2721
Hutchinson, A. J. L., 611, 658, 1033, 1421, 1855–7, 1861
Hüttel, R., 2585
Hyde, J. W., 1054

Ikeda, T., 402
Illinois Geological Society, 1159
Ilveskorpi, M., 2415, 2583, 2732
Ingalls, P. C., 543, 807, 815–16, 820–2, 824, 826, 831, 829–40, 980, 1152, 1217, 1574, 1577–9, 1590, 1751, 1804, 2009, 2016, 2019–20, 2027, 2034, 2270, 2463, 2618–19, 2622
Ingersoll, A. C., 2152
Ingham, E., 1506
Ingold, K. U., 182
Ingraham, R. B., 644, 660
Inouye, K., 2214
Inskeep, G. C., 1313, 1515
Ipatieff, V. N., 1514, 1665, 1667–9, 1678
Irving, R., 1268, 1513
Irwin, J. L., 1212
Isoda, H., 1278
Ivancheva, E. G., 1972
Ivey, F. E., 2191, 2709

Jackson, B. E., 232
Jackson, C. H., 786
Jackson, G. H., 784
Jackson, L. R., 1391
Jackson, P., 2235
Jacobs, E. C., 2143
Jacobson, H. A., 1049
Jaeckel, J., 1852
Jamison, E. A., 246
Janes, M. E., 434
Jansen, H. A., 2755
Jategan, P. N., 2151
Jauernik, R., 2534
Jaycon, E. K., 205
Jeanprost, C., 1439
Jeffrey, R. E., 1923
Jenkins, C. H. M., 1937
Jennings, A. S., 2705
Jennings, L. H., 2418, 2554
Jennings, T., 2045
Jensen, F. W., 2564
Jenson, J. A., 762
Jenson, W. R., 422
Jerrard, H. G., 709
Jewell, J. W., 402, 1866, 2344, 2681
Jewett, L. E., 1890
Johnson, A. D., 640
Johnson, B. L., 2600
Johnson, C. B., 1819
Johnson, E., 238
Johnson, G. C., 2727
Johnson, H. L., 1100
Johnson, J. H., 927
Johnson, K. H., 1194
Johnson, L. W., 1983
Johnson, P. H., 1047
Johnson, R. C., 1237
Johnson, S. P., 2631
Johnson, W. C., 1067
Johnson, W. E., 2048
Johnston, N., 1601
Johnstone, H. F., 1229, 2699
Johnstone, W. E., 2033
Joklik, A., 2350
Jolley, L. J., 413
Jones, A. G., 705
Jones, D. T., 756
Jones, E. N., 350
Jones, H. H., 245
Jones, J. W., 1630
Jones, L. C., 225
Jones, M. C. K., 1647, 1928
Jones, O. S., 1074
Jones, P. H., 1181
Jones, P. J., 347, 1766
Jones, R., 164
Jones, R. W., 338
Jones, T. S., 1168
Jones, W. C., 2678
Jordan, D. O., 1689
Jordan, G. D., 742
Jordan, G. F., 2616
Judd, D. B., 243, 1269
Judd, R. O., 1054
Jurczyk, K., 2308
Justice, W. H., 1199

Kachlik, K., 2202, 2513
Kadmer, E., 2403
Kaestle, F. L., 603
Kahl, A., 2610
Kahler, F. H., 2109
Kahler, H. L., 1109
Kaiser, C. P., 302
Kalichevsky, V. A., 1042, 1476, 1875–9, 2148, 2418, 2554
Kalis, K. P., 2571
Kalopissis, G., 443
Kaplan, W., 2695
Karr, A. E., 2130
Kartinen, E. O., 262
Karwat, E., 2571
Kastrop, J. E., 594A, 599, 874, 913–14, 1012, 1110, 1380
Katz, D. L., 2565
Katz, M., 1902
Kaveler, H. H., 2473
Kay, K., 1908
Kazanskii, B. A., 1453, 2377
Keane, C. C., 1398

Keefer, R. M., 1657–8
Keenan, V. J., 1963
Keiller, C. Q., 1089
Keller, G. V., 1180, 2038
Keller, W. O., 944
Kelley, M. D., 1229
Kellmer, B., 2718
Kellogg, M. W., 2153
Kelly, H. S., 359
Kelly, J. M., 1383
Kelly, R. B., 660
Kelm, E. F., 1692
Kelton, F. C., 571
Kemler, E. N., 85
Kendall, B. J., 2697
Kendall, D. L., 2155, 2155a
Kendall, G. F., 605
Kennedy, C. M., 434
Kenny, F., 1469
Kent, J. W., 379
Kent, R. H., 1922
Kenyon, R. L., 1313, 1515
Keplinger, C. H., 1365
Kerns, E. E., 1837, 2438
Kerr, P., 2095
Kerr, R. C., 2305
Kerver, J. K., 2046
Kestin, J., 1127, 2572
Kettenring, K. N., 637
Keuleyan, L., 2442
Khudyakov, G. N., 2363
Kidoo, G., 1511, 2149
Kiefer, G. C., 261
Kieffer, W. F., 2119
Kilpatrick, M. O., 2685
Kimball, C. S., 1965
Kimberlin, C. N., 2153
Kimberlin, C. W., 1503
Kimbrell, W. B., 339
Kimmel, A. L., 1114
Kincannon, C. B., 211
King, C. C., 2344
King, L. F., 2727
King, R. O., 723
Kingston, B. M., 1605
Kinney, C. R., 1521
Kinney, E. E., 1383
Kinney, P. T., 948
Kinsolving, W. C., 129
Kipp, E. M., 2727
Kirkbride, C. G., 2138, 2144, 2336
Kirkpatrick, C. V., 919
Kirshenbaum, I., 177
Kizer, C. A., 973
Klassen, J., 636
Klein, H., 2694
Klevens, H. B., 216
Klewski, F., 1366
Kline, V., 1210
Klinger, E. L., 887
Knaggs, E. A., 1316, 2702
Knapp, O. E., 1070
Knight, E. T., 1139
Knorre, G. F., 2561
Kobe, K. A., 436, 1443, 1896, 2186, 2562
Kobitzsch, R., 1302
Koch, E. F., 440
Kohl, A. L., 411
Kohrt, H. O., 2674
Kölbel, H., 649, 1884, 2571
Kolodziej, W., 277
Kolthoff, I. M., 237–8
Komarevsky, V. I., 1675, 2702
Koot, J. H. P., 178
Kornfeld, J. A., 823, 875, 1322, 1612–13, 1631, 1747, 1797, 2259
Korsmeyer, E. W., 1138
Kovacs, J., 657
Kraemer, A. J., 483, 2739
Kramer, M. G., 2595
Kranepohl, E., 2727
Kraus, A. F., 1220
Kraus, P., 2341, 2685
Krause, L., 2045
Krebs, R. W., 2350, 2694
Krenkler, K., 1699, 1955, 2205
Kress, K. E., 1471
Kresser, L., 2748
Kreulen, D. J. W., 2383
Krienke, C. F., 706
Krimmer, S., 1367
Krohn, I. T., 1030
Krom, C. J., 1272
Kroner, A. A., 1707
Kronig, R., 666, 673, 2321
Kronstein, M., 2732
Kruber, O., 2588
Krumbein, W. C., 2257
Kube, A. M. L., 1241
Kubista, W. R., 1219
Kuch, N. G. M., 157
Kudryashev, L. I., 1233
Kugler, E., 664
Kuhn, C. S., 170
Kulczycki, W., 281
Kumagai, S., 1278
Kunin, R., 2110
Kuropieska, J., 1436
Kurtz, R. B., 1469
Kurtz, S. S., 1039
Kusakov, M. M., 469
Kuwata, T., 2723
Kwan, T., 655–6

La Que, F. L., 763, 1111, 1985
La Rock, T. B., 131, 1629
La Rue, J. W., 1789
La Zerte, J. D., 1667
Lacey, W. N., 2704
Lacombe, P., 1982
Lacy, W. N., 625
Laddha, G. S., 1240
Lafitte, P., 185, 2167
Lafitte, M., 1913
Lahee, F. H., 4, 1621, 2093
Lamar, J. E., 538
Lamb, E. P., 2000
Lamb, F. W., 449
Lamb, J., 1930
Lamb, M. A., 429
Lammiman, K. A., 488
Landes, K. K., 1744
Landis, G. H., 132
Landsberg, G. S., 2377
Lane, H. W., 2089
Lane, T. B., 1936
Lang, B., 549
Lange, G., 2411, 2727
Langer, T. W., 2457
Lankford, J. D., 2219
Lanyi, B., 703
Larkey, C. S., 1384
Larsen, R. G., 1497, 1800
Larson, C. M., 1307, 2724–5
Larson, E. R., 2617
Lasky, B. H., 65
Lassiat, R. C., 2350, 2685
Latremouille, G. A., 224
Latter, F., 1991
Laubi, O., 2350
Laughlin, K. C., 1047
Laurence, L. L., 351
Layng, E. T., 177
Layton, C. W., 239
Leary, W. A., 1276
Le Boucher, B., 1982
Le Roy, D. J., 697
Le Roy, R. M., 2690
Leas, W. J., 2279
Leason, D. B., 2720
Lechler, P., 2208
Lechler, S., 1914
Leconte, R., 2571
Ledoyen, L. A., 2343, 2685
Lee, A. R., 752
Lee, R. D., 379
Lee, T. S., 238
Leese, C. L., 690
Leesemann, C. J. G., 2542
Lefèvre, P., 1888
Léger, A. E., 163
Leger, F. M., 2411, 2727
Lehman, E., 2357
Leidi, G., 1491
Leitch, L. C., 195, 1095
Leonard, J. S., 864
Lerner, B. J., 2535
Leslie, R., 1705
Lesser, M. A., 1966, 1969, 2428, 2596, 2745
Leva, M., 1414, 2691
Levedahl, W. J., 445, 2390
Levesque, C. L., 1681
Levey, H. A., 2386
Levin, H., 1460
Levina, P. Y., 2365–6
Levine, R., 1682
Levy, R. G., 2268
Levy, W. J., 2452
Lewis, J. B., 204
Lewis, R. W., 209, 218
Lichtenberger, R., 2364
Lieber, E., 1507, 2727
Liebhafsky, H. A., 1265
Lillie, S., 1567
Lindsay, F. K., 2104
Linford, A., 2351–2, 2455, 2556
Link, T. A., 325, 1585
Links, J., 1676
Linsenmeyer, J. C., 2660
Linstead, R. P., 667
Linz, B. F., 1809
Lippett, F., 713
Little, D. M., 1427, 1867, 2684
Livengood, J. C., 1276
Livingston, H. K., 2196
Ljunggren, G., 694
Lochman, C., 303
Lochte, H. L., 1670
Locke, L. C., 1368
Lockwood, R. P., 1584
Loebenstein, W. V., 2389
Logan, L. J., 97
Logwinuk, A. K., 2136
Lohmann, G., 2404
Lomax, E. L., 274, 792
London, A. L., 517
Long, E., 378
Long, R., 722
Longfield, J., 164
Longstroth, G. A., 1853–4
Looney, R. L., 2313
Lötgers, H., 1754
Louis, M., 1743, 2512
Lovell, S. P., 2749
Lovesay, A. C., 773
Lowe, A. S., 2735
Lowenstein-Lom, W., 1649
Lubbock, I., 1554
Lubinski, A., 1761
Luchak, G., 1854
Luckhardt, P. G., 926, 930
Lüder, J., 1910
Lugol, G., 553
Lukin, M. Yu., 1453
Lumerford, W. T., 762
Lundsted, L. G., 486, 2143
Luten, D. B., 1433
Luthe, W., 1478
Luther, H., 2375
Lykken, L., 452, 457, 1064, 1066
Lyles, A. C., 1901
Lymm, W. T., 1277
Lynch, C. C., 1677
Lynch, R. H., 120, 380
Lys, M., 1753
Lytle, W. J., 1376

MacDonald, D. M., 644, 660
MacDonald, G. C., 336
MacKenzie, K. J., 1282
MacLean, H., 640
MacPherson, J. H., 721
McAdams, U. R., 2350, 2694
McAdams, W. H., 617
McAllister, S. H., 1430, 2591
McAuslan, E. R., 2064
McAuslan, J., 1906

McCaleb, T. C., 1539
McCarthy, E. L., 577
McCarthy, J. E., 1008
McCaslin, L. S., 861, 2012
McClatchey, G. E., 551
McClellan, P. P., 1526
McClintoch, J. H., 2112
McClure, G. M., 1391
McCoy, A. W., 1745
McCoy, P. E., 252
McDermot, H. L., 157
McDonald, J. F., 970
McDowell, J. M., 353, 1377
McFadden, G., 1508
McFarlane, R., 945
McGarvey, F. X., 2105, 2110
McGlashen, W. A., 1917
McGrath, H. G., 2153
McGregor, D. K., 2549
McKay, R. F., 802
McKean, R. A., 631
McKeever, C. H., 1681
McKetta, J. J., 1370
McKim, F. L. W., 2737
McKinley, D. L., 1229
McKinney, C. M., 718
McLaren, F. H., 1271
McLaren, F. N., 1296
McLaren, K., 479
McLarty, D. M., 2069
McLaughlin, R. R., 1057
McLennan, L. W., 2407
McMahon, J. B., 1886
McMillan, W. G., 2156
McMillen, R. E., 1384
McNair, A. H., 1362
McNeil, O., 2686
Ma, C. C., 2225
Machter, A. G., 1980
Mack, C., 1437
Mack, G. W., 1714
Mackay, A. F., 1096
Mackay, D. K., 983
Maddams, W. F., 1959
Madden, H. J., 1030
Maganiello, E. J., 772
Magnus, A., 1452
Mahan, J. E., 2721
Maier, H., 2534
Main, T. C., 2153
Main, W. C., 331
Malcolmson, R. W., 2503
Mallinger, M. A., 1768
Mallinson, D. H., 1727
Mallison, H., 2313
Malm, C. J., 2155, 2155*a*
Malmstadt, M. U., 1069
Maltby, L. K., 2708
Manderfield, E. L., 637
Manilych, S., 754
Manley, C. H., 439
Manley, H. B., 2635
Manley, H. W., 1642
Mann, R., 852
Manning, E., 173
Mapes, G. S., 754
Mapstone, G. E., 690, 1041, 2146, 2398
Marchman, M., 2185
Mardles, E. W. J., 1690–1, 1939, 1950
Margules, D. D., 2099
Marhofer, E. G., 1530
Mariani, E., 1954
Marinesco, N., 2553
Mark, H., 1687–8
Marks, J. G., 2462
Markstein, G. H., 1402
Markunas, P. C., 1468
Maron, F. W., 2373
Marsel, C. J., 477
Marsh, W. C., 2194
Marshall, A. E., 1057
Marshall, C. H., 1247
Marshall, E. T., 1524
Marshall, M. E., 1116
Marshalle, R. P., 2350, 2741
Martin, D., 2051
Martin, H. D., 466
Martin, J. H., 236
Martin, J. R., 1891, 2582
Martin, O., 1701, 2412
Martin, P. M., 1959
Martin, R. H., 2080
Marx, A., 2415
Marx, O., 2741
Mason, J., 1401
Mason, J. A., 1786
Mason, J. F., 2293
Mason, S. G., 1898
Massey, W. P., 1369
Massiot, L., 2674
Masson, D. L., 1052
Mastin, R. G., 251
Matalon, R., 1318
Maters, C., 196
Mathai, A. O., 1693
Matheny, W. F., 1634
Matheson, G. L., 1503, 2685
Mathews, R. C., 2146
Mathieson, A. R., 1689
Matthews, R. R., 2580
Matthews, S., 1482
Mauchan, A. C., 733
Maughan, F. B., 1321
Maugis, P., 49
Maurer, L., 2416
Mauss, F., 215
Mavris, N. B., 1821
Max, N., 1420
Maxson, J. H., 1745
May, D. T., 915
Mayer, A. W. J., 1137
Maylott, A. O., 204
Mayne, J. E. O., 671, 1094
Mayo, F., 2237
Mazelli, J. R., 1860
Meckley, W. O., 267
Medcalf, E. C., 2679
Meehan, W. F., 1242
Meiklejohn, R. F., 961
Meissner, H. P., 2172, 2586
Melville, H. W., 187
Mena, R. O., 794
Menaul, F. L., 1108
Menaul, M., 199
Mench, J. W., 2155, 2155*a*
Menter, J. W., 671, 1934
Menzie, D. E., 918
Menzies, A. C., 1470
Merchant, M. E., 735
Mercier, V. J., 558
Meredith, H. H., 877, 1773
Merick, B. S., 1566
Merrick, C. M., 801
Merrill, R. C., 685
Merrington, R. S., 169
Merryfield, G. E., 1427
Mertens, E. W., 252
Mertes, R. W., 1425
Meshcheryakov, A. P., 430
Mesituka, G., 2212–13
Messersmith, A. H., 872
Métrot, R., 1188, 1771–2
Meyer, A. W., 1483
Meyer, F., 2414
Meyer, K., 2731
Meyer, W. E., 502
Middlebrook, V. E., 628
Middleton, A. B., 2107
Middleton, J. H. D., 775
Mikeska, L. A., 2727
Miles, A. L., 1641
Milhous, H. C., 1387, 2071
Miller, C. E., 1026
Miller, C. O., 2136
Miller, D., 2526
Miller, D. J., 1171
Miller, H. A., 2079
Miller, H. L., 449
Miller, J. C., 2749
Miller, R., 2606
Miller, R. J., 2701
Miller, R. L., 2084
Millett, W. H., 1499
Millidge, A. F., 678
Mills, G. A., 1656
Mills, K. N., 357, 563, 888, 897, 1203, 1757
Mills, O. S., 2184
Milne, A. A., 1942, 1948
Mina, F., 1173, 2060
Minnaar, H. W. T., 2730
Minton, A. S., 521
Mitchell, J., 455
Mitchell, L. E., 2216
Mizell, F. M., 1321
Möbius, D. K., 1557
Mock, F. C., 1347
Moe, H. S., 1070
Moehrle, E., 2415, 2741
Moeller, W. P., 2120–1
Mogerman, W. D., 763
Mohler, F. L., 435, 1058, 2371
Moles, H. R., 2003
Mondria, H., 645
Monicard, R., 273, 2715
Monrad, C. C., 1410
Montague, R. A., 1901
Montgomery, D. S., 165–7
Moody, C. L., 2258
Moody, G. B., 2083
Moore, A. C., 1941
Moore, J. W., 2253
Moore, N. P. W., 1277
Moore, R. J., 475
Moore, S. C., 881
Moore, W. B., 1221, 1822
Moos, J., 1915
Moot, C. W., 1194
Morales, M., 2536
Morazzani, A., 1376
Morey, F. C., 2354
Morgan, F., 353
Morgans, W. M., 256
Morgenthaler, A. C., 2549
Morin, R. D., 2698
Moritz, C. A., 2466
Morl, Y., 2183
Morley, R. H. H., 2727
Morningstar, E. E., 1245
Morris, J. I., 335, 1013
Morris, L. C., 2687
Morris, R. C., 251
Morris, T. B., 1592
Morris, W. E., 724
Morris, W. J., 1455
Morris, W. L., 695
Morrison, G. H., 1073
Morrison, H. L., 1897
Morrison, P. W., 960
Morrow, M. R., 2542
Morse, H. M., 1796
Morse, R. A., 2478
Mortimer, R. H., 1100
Morton, F., 525
Morway, A. J., 1088, 1507
Moserman, M. A., 2153
Moss, E., 1945
Mossop, S. C., 334
Mott, N. S., 258
Mottes, J. R., 1411
Moult, E. S., 1729
Mueller, N. F., 2705
Mukherjee, N. R., 149
Mulder, J., 2322
Mulder, J. C. T., 1640
Mullen, J. W., 2605
Müller, H., 2718
Munday, C. W. A., 2727
Mundt, H. W., 1534–5
Munger, H. P., 2005
Munn, G., 1660
Muraour, H., 662
Murchison, E. A., 2058
Murphree, E. V., 1530
Murphy, C. M., 1498, 1501, 1504
Murphy, W. I. R., 2215–16
Murray, C. A., 1974
Murray, G. E., 1
Murray, H. A., 1490

Murray, H. D., 496
Murray, H. G., 1025, 1230
Murray, S. A., 2002
Musgrave, F. F., 468
Muskat, M., 1377, 1788
Must, W. C., 2211
Myddleton, W. W., 1527
Myers, G. E., 2362
Myers, R. J., 2430

Nabors, W. N., 2045
Nachod, F. C., 227
Nagelstein, E. W., 406
Naldrett, N. F., 902
Nance, W. T., 561
Naragon, E. A., 1434
Naruishkina, T. I., 2396
Neal, R. C., 964
Neale, S. M., 691, 1951
Nederbragt, G. W., 437
Neithammer, J. H., 271
Nelson, G. A., 493
Nelson, M. D., 340
Nelson, R. H., 2599
Neppe, S. L., 2729
Nettlenbusch, L., 2350, 2690
Neumann, E., 1953
Newitt, D. M., 2520
Nichol, R. J., 2737
Nichols, H. B., 147
Nichols, I. K., 1746
Nichols, J. P., 1321
Nichols, P. L., 240
Nicholson, C., 463
Nicholson, H. J., 737
Nicol, H., 405
Nicolls, W. E. W., 1995
Niebusch, R. B., 1512
Nielsen, R. F., 75, 77, 918, 948, 950, 1206, 2049
Niementowska, I., 2008, 2097
Niemientowski, S., 278
Ninos, N. J., 2408
Noakes, G. E., 449
Noguchi, S., 2723
Nord, M., 137, 1045, 2114
Nordell, E., 934
Norman, N. E., 2690
Norman, W. S., 622
Norrish, R. G. W., 1458
North, A. G., 2602
Norton, D. G., 1100
Nostrip, Inc., 2208
Nottes, G., 2398
Novikov, S. S., 432, 2396
Nowell, L. A., 1298
Nunn, L. G., 1542
Nutter, I. E., 1830–1
Nygren, W. E., 44

Oates, J., 1820
Oberg, C. H., 1182
Oberseider, J. L., 2448
O'Connor, P. E. T., 1214
Oden, E. C., 1244
Odenorantz, J. T., 203
Offutt, E. B., 451
Ogden, L., 806
Ogilerie, J. D. B., 1859
O'Halloran, R., 1088, 2727
Oldham, G., 698
O'Leary, P. T., 2124
Oleves, R., 113
Oliensis, G. L., 1312
Olson, E. H., 774
Olson, R. L., 2160
O'Malley, T., 329
O'Neal, M. J., 214
Onyszkiewicz, Z., 2035, 2040, 2042
Op ten Noort, L. H., 2652
Opie, T. L., 1400
Oppelt, W., 2318
Oppenheim, A. K., 517
Orchin, M., 1682, 2673
Ormrod, O., 659
Orr, R. J., 1870–1
Osborn, O., 1538
Oschatz, F., 2694
Osmun, R., 2111
Osoba, J. S., 2046
Ostaszewski, J., 1373
O'Sullivan, J. K., 1358
Othmer, D. F., 2120–1, 2671
Ott, C. J., 1100
Ott, W. L., 1096
Otvos, J. W., 1683
Ouelet, C., 163, 1893
Ouellet, L., 1893
Owen, J. J., 177
Owen, L. D., 104
Owens, W. W., 2478
Ozaki, T., 462
Ozanne, H., 847

Pacific Section, A.A.P.G., 1160
Pacifico, C. R., 486
Packie, J. W., 253
Padovani, C., 1491, 1516
Paes-Barreto, C. E., 2317
Page, B. M., 2462
Page, B. S., 2153
Page, J. H., 585
Pagliassotti, P. G., 1475
Palit, S. R., 666
Pallez, A., 1442
Palmer, R. C., 686, 696
Pamely-Evans, O. G., 618, 1441
Pamfilov, A. V., 1972
Paraszczak, W., 1372
Parker, J. L., 646
Parker, M. E., 1324, 1531–2, 1715, 1720, 1976–7, 1986–8, 1990, 2222–4, 2432–7, 2603–4, 2750
Parker, R. W., 1542
Parks, A. S., 951
Parks, G. B., 332
Parks, T. D., 452, 457–8, 1064, 1066
Parrish, D. R., 2478
Parsons, C., 868
Partington, J., 284
Partridge, W. J., 1085
Passino, H. J., 1040
Pastell, D. L., 1927
Pasternack, D. S., 2728
Pastonesi, G., 1564
Patterson, J. A., 156, 1100
Patterson, O. L., 932
Pattison, J. N., 2703
Patton, J. L., 2058
Pawlikowski, S., 175
Paxton, C. E., 2753
Payne, A. L., 2468
Payne, J. M., 561
Payne, T. G., 1171
Pearce, J. A., 1859
Pearson, H., 1729
Peavy, C. C., 2685
Peel, D. H. P., 2694
Pelipetz, M. G., 2142, 2159, 2692–3
Penn, M. B., 1384
Penner, S. S., 2161
Pennington, R. E., 436, 1443, 2186, 2562
Percival, W. C., 1666
Peres, E. M., 2225
Perkins, J. A., 559
Perry, G. L., 2727
Perry, J. A., 208, 1474
Peters, J. G., 1088
Peterson, E. A., 1100
Peterson, W. H., 475, 1430, 2668
Petrov, A. D., 430, 1448
Petrovicki, H., 2581
Petrusevich, A. I., 1303
Phibbs, M. K., 188
Phinney, J. A., 2153
Piatkiewicz, R., 280
Pickard, J. A., 1046
Pier, M., 2546, 1869
Pierce, C., 1654
Pierotti, G. J., 1420, 2737
Pierson, R. M., 2206
Piganiol, P., 1973
Pigford, R. L., 2131
Pilz, K., 2350
Pines, H., 1514, 1665, 1667–9, 1678
Plantfeber, J. M., 2411, 2727
Platt, A. M., 2563
Plaza, L., 243, 1209
Plomley, K. F., 682
Plyler, E. K., 429, 2370
Podbielniak, W. J., 1904–5
Poitz, H. A., 266
Polumbus, E. A., 2081
Polyakov, G. M., 2122
Poore, J. N., 882
Porsche, F. W., 1475
Portch, G. G., 1989
Porter, J. A., 570
Porter, L. E., 1798
Porterfield, D. C., 1213
Poster, F. W. B., 2346, 2690
Potter, C., 2209
Pound, G. S., 1708
Pounder, C. C., 387
Pourbaix, M., 260
Powell, C., 851
Powell, J. I., 1133–6, 1351, 1559
Powell, J. S., 1917
Powers, W. D., 1382
Prange, J. A., 1103
Pratt, H. R. C., 149, 1636–8
Prehn, W. L., 2477
Preis, H., 2376
Preu, F., 761
Prevost, C., 154
Pribuitkova, N. A., 1447
Price, J. F., 1313, 1515
Price, P. H., 317
Price, W. C., 1906, 2180
Pringle, T., 1508
Prins, J. A., 2322
Priznar, M., 227
Proctor, J., 1769, 1793
Prosen, E. J., 2373
Prosser, L. E., 2511
Pruna, M., 1962
Prusick, J. H., 566, 935
Pryor, C. C., 397
Pryor, N. J., 671
Purcell, W. R., 573
Purdie, W. H., 1725
Puryear, O. P., 251
Pusack, G. W., 725
Putman, J. H., 1523
Puzitzkil, K. V., 424, 1451

Quarendon, R., 460
Quayle, A., 1604
Quill, J. S., 2607
Quin, D. C., 678
Quinn, J. F., 708
Quiquerez, J., 2694

Rabinowicz, E., 1949
Raeithel, A., 2588
Ragatz, E. G., 1423
Rager, R., 197
Raguideau, —, 1882
Rahme, H. S., 2050
Rahmes, M. H., 348
Raiford, P. K., 2169
Raimondo, E., 2712
Rall, C. G., 949, 1205
Ralph, H. D., 2047
Rama das Guha, S., 1445
Ranauto, H. J., 1967
Raphael, R. A., 690
Rapoport, L. A., 2279
Rappen, L., 2415, 2741
Rasmussen, R. R., 1239
Ratliff, F. T., 141
Rau, W. W., 1749
Raviolo, V. G., 1944
Ravner, H., 1501
Rawlins, E. B., 1285

Rea, H. C., 834
Read, D., 1489
Reamer, H. H., 2187, 2704
Reamer, T. E., 2753
Reavell, B. N., 2521
Records, L. R., 2276
Redgrove, E. R., 1284
Redlein, W. H., 2112
Redman, W. J., 896
Redmond, W. P., 2639
Reed, E. C., 364
Reed, J. A., 877, 1773
Reed, P., 601, 994, 1145, 2311
Reed, R. M., 646
Reents, A. C., 2106, 2109
Reese, R. M., 2371
Reeves, E. D., 2397, 2721
Reeves, F., 317
Reichertz, P. P., 355
Reid, E. B., 1907
Reid, L. S., 351, 570, 577
Reider, C. M., 1420, 2737
Reilly, P. M., 2672
Reimering, W. T. B., 369
Reiner, M., 670, 1092
Reis, T., 446
Reisenfeld, R. C., 1978
Reisner, J. H., 1912
Reitz, O., 2350, 2694
Remke, M. A., 575, 924
Rend, D., 1829
Renner, A. J., 642
Renquist, M. R., 1980
Renshaw, W. G., 261
Resen, F. L., 1646, 2338, 2348
Retailliau, E. R., 1928
Reynolds, B., 1926
Reynolds, J. G., 2179
Reynolds, J. M., 344
Reynolds, W. L., 640
Reysen, W. H., 1502
Ricardo, H., 727
Ricardo, H. A., 1928
Ricardo, H. R., 1128
Rich, J. L., 1153, 2614
Richards, H. G., 2054
Richardson, D. M., 1472
Richardson, J. G., 2046
Richardson, R. W., 1503
Richter, F. P., 2727
Rick, A. W., 1956
Riddick, J. A., 1468, 2178
Ridgeway, R. S., 1840
Ridlington, J., 2654
Riediger, B., 2331
Rieman, W., 203
Riester, W. F., 1055
Riesz, C. H., 2158
Rietema, K., 1249
Rigden, P. J., 1092, 1262
Riggs, O. W., 2356
Riggs, W. R., 162
Riley, M. L., 1016
Rischbieth, J. R., 714
Risk, T. H., 2576
Roach, A. E., 740
Roach, D. A., 2633
Roach, T. G. H., 2312
Roads, W. E., 606
Roark, R. C., 1709
Roberts, A. E., 1749
Roberts, S. M., 1670
Robertson, G. M., 2188
Robertson, H. A., 1898
Robertson, R., 1030
Robinson, C. Y., 2560
Robinson, P. A., 2549
Robinson, S. P., 2734
Robinson, W. E., 758, 2502
Robb, J. C., 187
Rochow, T. G., 1483a
Rockwell, R. A., 2662
Rocky Mountain Assn. of Geologists, 1161
Roe, R. M., 448
Roe, R. P., 925
Roegiers, M., 2706
Roehner, T. G., 747, 2385
Roensch, M. M., 1920
Rogers, D. T., 2727
Rogers, F. T., 1897
Rogers, R. M., 1339
Rohrman, F. A., 1328
Rokand, L. O., 957
Roliff, W. A., 2085
Rolshausen, F. W., 74
Roose, M. B., 767
Rose, A., 154, 1076, 1237, 1418, 1464
Rose, G. R. F., 1148
Rose, H. E., 2453
Rose, R. A., 2324
Rose, W., 1782, 2277
Rosenberg, S., 1454, 1457
Rosenthal, M., 264
Ross, D., 2188
Ross, D. H., 2426
Rossini, F. D., 434, 663, 1461, 2373
Rössler, E., 2571
Rothfus, R. R., 1410
Rowe, R. A., 2357
Rowley, L. N., 269
Rubin, B., 1286, 2406
Rubinstein, A. M., 1447
Rudd, H. W., 1097
Ruebensaal, C. F., 1711
Ruegg, F. W., 441
Ruehl, W., 2281
Rugh, K. W., 2252
Ruhemann, M., 414
Ruka, R., 2168
Rumble, F. H., 621
Rumpf, K. K., 627
Rupp, W. H., 253, 1030, 1081
Rush, E. H., 1533
Russell, G. F., 1834
Russell, R. G., 206
Russell, W. A., 1276
Russell, W. L., 749
Ruther, W. E., 1675
Rutherford, J. T., 1507
Rutherford, R. L., 1582
Rutschi, K., 1413
Ryder, E. A., 1903
Ryder, H. M., 568, 921, 1102–3
Ryland, A., 2552
Rzasa, M. J., 1787, 2278

St George, A. J., 1279
Saal, C., 1921, 1999
Sachanen, A. N., 1431, 1530, 2411, 2727
Sadler, L. R., 759
Sage, B. H., 442, 625, 942, 1032, 1774, 2697, 2704
Sale, B., 248
Salomonsson, G., 2423
Salton, M. R. J., 1318
Salvi, G., 1486, 1516
Samuelson, M. J., 1274
Sanders, H. L., 1316
Sanderson, J. P., 1970
Sands, A. E., 1246
Sanin, P. I., 1360
Sarjeant, R. J. 2238
Saunders, C. E., 1504
Saunders, K. D., 1596
Saunders, K. W., 2134
Savage, R. T., 2350, 2685
Savidge, L. N., 1732
Savin, J. W., 271
Savoy, M., 266, 2678
Sawyer, F. G., 1245
Sayre, A. T., 79
Schabarum, B. R., 1184
Schaeffer, J. H., 174
Schaerer, A. A., 2210
Scheibel, E. G., 2551
Scheider, K. W., 1263
Schenk, J., 2322
Scherff, W., 2585
Schertel, L., 2342, 2685
Schieferdecker, A. A. G., 1808
Schiermeier, K. F., 266
Schiff, H. I., 1895
Schiffman, L., 917
Schiller, J. C., 2350, 2694
Schindler, H., 1849
Schlesinger, M. D., 2601
Schmatz, J. P., 2050
Schmerling, L., 2734
Schmid, C., 1775
Schmidt, H., 852
Schmidt, J., 2571
Schmidt, L. D., 1246, 2140
Schmitz, W. R., 1659
Schneider, V., 199
Schneider, W. G., 2100
Schnur, F., 2686
Schnurmann, R., 687, 1455, 1940, 1959, 2382
Scholz, H., 2571
Schott, J. E., 1088
Schrage, R. W., 1449
Schreiber, W., 1494
Schuftan, P. M., 2690
Schultze, G. R., 1915
Schulz, G., 1957, 2439
Schulze, W. A., 1433, 2721
Schuppli, H. M., 1755
Schuster, F., 2574
Schutte, A. H., 2685–6
Schwartz, F. G., 2198
Schwarz, F., 2690
Schwoegler, E. J., 2143
Scivier, J. B., 2326
Scofield, R. C., 1850
Scott, C. G., 707, 2381
Scott, E. J. Y., 1894
Scott, J. W., 1003
Scott, R., 1319
Scovill, W. E., 2147
Scrafford, B., 2078
Sebastian, J. S., 2140
Sebastin, J. J. S., 2158
Sedlake, V. A., 434, 701
Seebohm, H. B., 2332, 2674
Seed, K. W., 1641
Seeley, D. H., 2276
Seely, P. B., 2197
Seger, F. M., 1431
Seligman, B., 1679
Selim, F. E., 2180
Selk, E. L., 1364
Sellers, E. S., 2393
Seltzer, K. P., 2742
Sen, J. N., 666
Senecal, V. E., 1410
Serfass, E. J., 202
Sergienko, S. R., 1360, 2347
Serrill, J. L., 1890
Servais, P. C., 2594
Setterington, D. T., 287
Severy, C. L., 2069
Sexauer, W., 2350, 2690
Shand, E. W., 2685
Shankland, R. V., 1242
Shanley, W. B., 2687
Sharrick, A. N., 2061
Shaw, E. W., 2291
Shaw, S. F., 920
Shaw, T. M., 672
Shelton, J. R., 2176
Shepard, E. R., 1104
Shepherd, F., 41
Shepherd, J. M., 1781
Shepherd, M., 200–1
Sheppard, N., 2181
Sheppard, R., 375
Sherbourne, J. E., 556
Sherwood, T. K., 1232
Shida, S., 2183
Shields, H., 1330
Shimkin, D. B., 701
Shipp, G. C., 2520
Shmidl, A. J., 2734
Shoemaker, B. H., 2727
Shooter, K. V., 1946
Showalter, W. E., 1792
Shreve, R. N., 2601

Shulkin, N. I., 432, 2396, 2420
Shultz, J. F., 1679
Sidwell, C. V., 560
Siebert, E., 2534
Siedentop, R., 1700
Sielaff, R. L., 2745
Sieplein, O. K., 1721
Siever, R., 1363
Sikora, F., 2539
Simon, W., 2153, 2346, 2350, 2685, 2694
Simons, C., 689
Simons, E. L., 2450
Simons, J. H., 254
Simons, R. L., 846, 1739
Simpson, J. B., 1818
Sims, L. G. C., 1091
Sinclair, E. A., 2206
Sinclair, W. G., 985, 2482
Sinertz, C., 164
Singer, E., 1231
Singleterry, S. R., 2174
Siniramed, C., 1486, 2163, 2712–13
Sipple, H. E., 1507
Sipprelle, E. M., 2217
Siroff, M. P., 1336
Sittig, M., 632, 1035, 1931, 2541
Skinner, E. T., 383
Skolnik, H., 2532
Slater, L. E., 1651
Slattery, J. J., 587
Sleeswijk, A. W., 1027
Slobod, R. L., 1479, 2477
Sloss, L. L., 2612
Small, A. B., 1088
Small, N. J. H., 2550
Smethurst, J., 257
Smith, B. B., 880
Smith, B. F., 1500
Smith, C. R., 219
Smith, C. W., 97–8, 1100, 1568
Smith, D. C., 1504
Smith, D. M., 455
Smith, E. A., 2244, 2409
Smith, F., 1184
Smith, H. G., 1088, 2190, 2721
Smith, H. M., 718, 1477, 1487, 2006
Smith, J., 1736
Smith, J. C., 1444, 1692, 2550
Smith, J. D., 1911
Smith, J. M., 637, 1240, 2536
Smith, J. R., 217, 219
Smith, L. K., 2529
Smith, N. A. C., 718
Smith, N. L., 1403, 1501
Smith, O. H., 1483
Smith, P. S., 1315
Smith, R. N., 1654
Smith, R. V., 1105, 1784
Smith, S. S., 133*a*, 135, 1533
Smith, T. E., 2154
Smith, V., 1357
Smith, V. A., 450
Smith, V. R., 252
Snavely, P. D., 1749
Sneddon, R., 986
Snell, F. D., 1965
Snyder, R. E., 1072
Sobotka, H., 1454, 1457
Soden, W. S., 620
Sohns, H. W., 2216
Somerford, S. D., 2350
Somerton, W. H., 583
Sorg, L. V., 451, 1330
Souders, M., 2734
Soule, L. F., 434
South Texas Geographical Society, 1167
Spain, H. H., 1015
Spakowski, A. E., 1063
Spalding, D. B., 1925
Spangler, M. G., 750
Spear, N. H., 1466
Spectroscopic Panel, Institute of Petroleum, 2182
Spence, L. U., 150
Spencer, G. B., 2043
Spencer, R. W., 2107
Spice, W. H., 365
Spicer, W. E., 2350, 2694
Spindt, R. S., 1338
Spinn, C. W., 2536
Spooner, D. F., 181
Sprake, C. H., 2567
Sproule, L. W., 2727
Spurr, R. T., 1938
Squier, J. P., 1011
Squires, F., 349, 922, 926, 930, 1191, 1195
Stacy, S. J., 1534–5
Stahl, C. D., 77, 950, 1206
Stamm, A. F., 2000
Standard Oil Development Co., 2153
Stanfield, K. E., 2215, 2218
Stannett, A. W., 1960, 2360
Staples, R., 354, 959
Starr, C. E., 141
Staveley, L. A. K., 659
Steachie, E. W. R., 1894–5
Stear, D. S., 1783
Stearns, R. S., 2600
Stebel, A., 2571
Steele, J. B., 585
Stehman, C. J., 1666
Steig, M. H., 1746
Steiner, H., 414, 2544
Steinhardt, R. G., 202
Steinitz, E. W., 467
Stenzel, H. B., 2465
Sterne, W. P., 2073
Sterrett, E., 301, 330, 550, 595, 788, 866, 1625, 2355
Stevens, D. E., 252
Stevens, D. G., 2688
Stevenson, D. P., 1672, 1683
Stevenson, R. E., 546
Stewart, A. D., 796
Stibolt, V. D., 2550
Stiebling, E., 2686
Stiles, H. A., 650
Stillman, N., 1085, 1088
Stine, H. M., 172
Stirling, W. T., 2419
Stivers, F. O., 139
Stokes, C. A., 1314, 1974
Stoll, H., 1485
Stone, E. E., 2174
Stone, F. G. A., 688
Stoops, C. E., 1433
Storch, H. H., 1679, 2691
Storey, J. B., 2749
Storment, J. E., 171
Stormont, D. H., 376, 811, 1017, 1051, 1209, 1611, 1815, 2461, 2640, 2754
Stovall, W. S., 358
Stover, W. A., 1530
Strachan, M. N., 2749
Strand, C. P., 1425
Strange, C. D., 785
Streeton, R. D., 733
Strehlau, D. R., 1665
Streiff, A. J., 434
Strieder, E. H., 1512
Stripling, J. B., 1437
Stromquist, D. M., 2106
Strong, F. C., 202
Strong, R. E., 1361
Stroupe, J. D., 215
Stuart, A. H., 470
Stuart, E. B., 1253
Stubbs, F. J., 182
Stuirikovich, M. A., 2122
Stupel, H., 2598
Sturgess, E. J., 2240
Sturm, P. W., 2048
Sudholz, L. H., 754
Sugimoto, R., 2721
Sukmarowski, S., 279
Sulimirski, S. L., 72
Sullivan, R. D., 1432
Sullivan, R. J., 1015
Sumerford, S. D., 1047, 2350, 2694
Supple, G. H., 463
Suter, H. R., 2595
Sutherland, R. E., 2340
Sutherland, R. G., 208
Swain, S. E., 74
Swaminathan, V. S., 995, 1018, 1044, 1222, 1825, 1828, 1883, 2515, 2658, 2759–60
Swaney, M. W., 1039, 1432
Swanston, K., 686, 696
Swartz, F. M., 76
Sweatt, C. H., 2457
Sweeney, W. J., 415
Sweetser, S. B., 2694
Swesnik, R. M., 307
Swinehart, R. W., 74
Szederes, J., 2372
Szura, T., 1366

Tait, G. W. C., 653
Taliaferro, D. B., 949, 1205
Talley, S. K., 2727
Tanaka, I., 2183, 2676
Tancig, W. J., 450
Tapper, W., 1897
Tarn, W. H., 1680
Tarner, J., 2473
Tarrant, L. H., 2272
Tasman, I., 1177
Tate, C. C., 1842, 2256
Taub, A., 497
Taverne, N. J. M., 2037
Taylor, C. F., 1276
Taylor, E. S., 1276
Taylor, F., 2714
Taylor, G. W., 1096
Techetmayr, O., 2350
Teller, E. T., 2156
Temmel, A. C., 333
Ten Eyck, E. H., 2671
Ternpoll, M., 2317
Terres, E., 2538
Tertil, S., 2590
Tetlow, K. S., 1906
Tetlow, N., 2325
Thagard, W. T., 1014
Thawley, L. H., 1388
Thode, E. F., 2172, 2586
Thode, H. G., 710
Thomas, B. W., 1900
Thomas, R. M., 1088
Thomas, W. A., 624
Thompson, C., 398
Thompson, C. J., 217, 1477
Thompson, C. N., 1071, 1268, 1513
Thompson, H. F., 1029
Thompson, J., 2105
Thompson, L. J., 1534–5
Thompson, R. B., 1039, 2201
Thorne, H. M., 483, 2215, 2218, 2739
Thornton, D. P., 612, 651, 2656
Thorp, A. B., 2654
Thorpe, R. E., 2727
Thorpe, T. C. G., 2417
Thrower, E. N., 1092
Tierney, W. T., 1926
Tignor, E. M., 2045
Tillery, J. H., 574
Tillington, W. J., 62
Timmer, J. H., 152
Timofeeva, E. A., 2420
Timothy, P. H., 2645
Tingle, E. D., 1939
Tiratsoo, E. N., 345, 804
Titani, T., 2212
Tobin, D. J., 2193
Tobinson, G. T., 2139
Tolin, S., 2671
Tompkins, L. G. R., 2690
Tookey, W. A., 1295

Topchiev, A. V., 1360
Topping, A. D., 879, 1596
Torrey, P. D., 84
Tournaire, R., 1510
Townsend, A. A., 343
Trafford, E. le M., 1811
Trail, J. A., 739
Traver, W. B., 2456
Trawinski, 276
Trenne, H., 1264
Trexel, C. A., 863
Treybal, R. E., 2133
Trigg, W. M., 179
Troyan, J. E., 169
Trube, A. S., 1374
Trusler, R. B., 2747
Tsui, T. K., 2121
Tucker, P. W., 2570
Tucker, R. C., 2082
Tuddenham, W. D., 220
Tudge, A. P., 710
Tufts, J. D., 620
Tulsa Geological Society, 1158
Tulupova, E. D., 432
Turbin, K., 626
Turner, W. R., 1514
Turriziani, R., 1954
Turska, E., 1571
Turunen, W. A., 779
Tuttle, R. B., 1142–3, 1561, 2333, 2454
Tyler, C. A., 1317
Tyminski, W., 1762
Tyrer, F. H., 1732
Tysall, L. A., 1097

Ubbelohde, A. R., 2559
Ubbelohde, R., 184
Uhl, W. C., 634
Umbach, P. H., 2053
Umstätter, H., 2380, 2387
Updegraff, C., 646
Upton, P. B. G., 461
Urban, W., 1868
Uren, L. C., 991

Valatin, T., 757
Valentine, S., 2137
Valerius, C. N., 1179
Van den Ende, J. C., 530
Van der Waarden, M., 438, 1255
Van der Zijden, M. J., 530
Van Dijck, W. J. D., 1440
Van Dyke, O., 1599
Van Dyke, O. W., 68, 899
Van Gorcum, A. H., 719
Van Hinte, J. E., 530
Van Krevelen, D. W., 183
Van Loon, W., 2718
Van Nes, K., 2394
Van Riemsdijk, A. J., 2358
Van Rysselberghe, P., 260
Van Steenis, J., 2358
Van Tiggelen, A., 194
Van Vliet, C. D., 1830–1
Van Wingen, N., 598, 947, 1198, 1601
Van Winkle, J. L., 251, 418, 1239, 1918
Vand, V., 2175
Varga, J., 661
Varnell, D. D., 339
Vaughan, J. R., 932
Vaughan, T. H., 486
Vaughan, W. J., 2074
Vaughn, J. C., 936
Vaughn, T. H., 2143
Veatch, F., 2688
Vellinger, E., 273
Verberg, F., 437
Verschoor, H., 665
Vichnievsky, R., 248, 444
Vickers, H. H., 1524
Vickery, D. S., 2566, 2707
Vierling, A., 1759
Vietti, W. V., 341
Viland, C. K., 409, 639
Vitter, A. L., 16
Vold, M. J., 1425
Vollett, R. W., 1057
Von Bethmann, M. F., 2686
Von Croy, S., 1179
Von Estorff, F. E., 2302
Von Füner, W., 2346, 1685
Von Segesser, A., 2508
Voorhies, A., 2153
Voreck, W. E., 1874
Voss, N. A., 934
Vriens, G. N., 2679

Wachal, A., 2539
Wachal, A. L., 503
Wachter, A., 1085, 1088, 1980, 1981
Wachtman, H. C., 1765
Waddill, P. M., 1867, 2084
Wade, A., 328
Wade, O. W., 1115
Wagner, C. D., 1672, 1683
Wagner, C. R., 2737
Wagner, H. W., 1086
Wagoner, G. E., 2271
Walczynski, J. Z., 2004
Walin, C. R., 212
Walker, G. W., 2462
Walker, O. J., 168
Wally, F., 2533
Walsh, T. J., 2115
Walstrom, J. E., 909
Walter, A. W., 890
Walter, R. B., 1112
Walter, R. N., 456
Walters, E. L., 1507
Walton, J. S., 2160
Wanderer, E. T., 2220
Wanenmacher, J. M., 1365
Warburton, H., 1297
Ward, A. F. H., 691, 1951
Ward, C. C., 2198
Ward, S. G., 683–4, 1062
Warner, W. C., 2176
Warren, T. E., 1952
Warot, J., 1359
Waterman, H. I., 702, 2358
Watkins, F. M., 490
Watkins, J. W., 1102, 1371
Watkins, T. E., 340
Watson, F. J., 251
Watson, J. C., 107
Watson, K. M., 162
Watson, M. S., 82, 966, 1375
Watson, R. W., 1037
Weatherburn, A. S., 1148
Weatherford, W. D., 1419
Weaver, E., 1005
Weaver, E. R., 2378
Weaver, P., 1162
Webb, M., 1043
Weber, G., 159, 643, 1147, 1406, 2245, 2282, 2548
Wechsler, H., 1687–8
Weeks, L. G., 89, 1573
Weghofer, H., 1259
Weichert, J. P., 899
Weil, H., 1435
Weinaug, C. F., 1056
Weininger, J. L., 2100
Weir, T. P., 211
Weisel, C. A., 1293
Weiss, F. T., 209, 218
Weiss, H., 527, 1887
Weller, S., 2159, 2692–3
Wellc, G. T., 1832
Wells, J. H., 207
Wells, N. C., 893
Wender, I., 1682
Wender, J., 2673
Wenger, W. J., 717
Wengerd, S. A., 1748
West, F. B., 2549
West, J. A., 927
West, J. M., 1003
Westham, B. J., 337
Wetzel, L. A., 1081
Whalley, M., 667
Wheeler, H. P., 1916
Whetstone, R. R., 1100
Whisman, M. L., 717
Whitacre, C. H., 2147
White, C. L., 1025, 1230
White, E. D., 1645
White, P. C., 2456
White, R. L., 1329
White, R. R., 1256
White, S. H., 1081
White, T. A. B., 1733
Whiteley, R. S., 1503
Whiting, L. R., 769
Whitmore, F. C., 1666
Whitmore, R. L., 683–4, 1062
Whittet, K. J., 169, 1025, 1230
Whittle, G., 2033
Widmaier, O., 215
Wiedenmayer, C., 2395
Wiegandt, M. H., 142
Wiesner, K., 644, 660
Wilbert, L. J., 1
Wilford, A. T., 1924, 2401
Wilgard, F. J., 774
Wilhelm, R. H., 638, 1231, 1243, 2137
Wilk, Z., 2509
Wilke, C. R., 1235
Willard, B., 546
Willard, B. J., 1539
Willcox, O. W., 731, 2424
Wille, H., 2415, 2589, 2741
Willett, F. R., 1371
Williams, A. E., 1304–5
Williams, C. E., 2472
Williams, C. R., 2340
Williams, E. P., 1583
Williams, H. L., 1870–1
Williams, L. W., 1851
Williams, M., 1015, 1187
Williams, N., 857
Williams, R. H., 1784
Williams, T. J., 154, 1237, 1418
Williamson, I., 1459
Williamson, L., 435, 1713
Willingham, C. B., 434, 701
Willis, C. C., 518
Willits, C. O., 2164
Wilner, T., 604
Wilson, B. S., 2402
Wilson, D. A., 1789
Wilson, E. D., 2291
Wilson, G. M., 596, 615, 730, 889, 1402
Wilson, G. S., 1386
Wilson, J. G., 1980–1
Wilson, M. E., 41
Wilson, S. W., 156
Wilt, W. A., 227
Windle, J. J., 672
Winfiele, T. M., 539
Winhold, E. J., 1853
Winkler, C. A., 165–8, 1036, 1038, 1859
Winkler, F., 2350, 2721, 2741
Winslow, E. H., 1265
Wirth, G., 635
Wirth, L., 2111
Wirth, L. F., 2104
Wise, G. E., 2194
Wise, P. H., 1664
Withers, J. G., 464, 503
Withycombe, E., 1090
Witschakowski, W., 453
Witthuhn, H., 1915
Wojciechowski, M., 1655
Wojnar, J., 278
Wolf, M., 1411
Wolf, V., 2332
Wolfe, C. L., 1338
Wolff, W., 2350, 2694
Wolfson, M. L., 2142
Wolosewick, F. E., 384, 597, 1823, 2516, 2664
Wood, B. B., 2278
Wood, D. G. M., 2361

Wood, E. B., 2057
Wood, H. J., 1345
Worden, J. S., 620
Worster, R. C., 2511
Wotman, H. R., 1007
Wright, G. F., 1059
Wright, J. F., 405
Wuche, E. H., 1719
Wyllie, M. R. J., 1791
Wynkoop, R., 1243
Wyszynski, Z., 73

Yang, K. H., 423
Yard, W. B., 1408, 1839
Yeomans, A. H., 2599
Yoffe, A. D., 732
Yoshida, F., 2676
Young, D. P., 680
Young, F. S., 1006
Young, J. F., 2752
Youssef, I., 1079
Yu, K. T., 1253
Yuster, S. T., 79

Zachen, F., 1399
Zager, S. E., 2108
Zechetmayr, O., 2694
Zelinskii, N. D., 424, 1451
Zlminova, N. I., 1446, 2359
Zimmer, J. C., 2753
Zimmerli, A., 1450
Zisman, W. A., 1456, 1498
Zürcher, M., 1910
Zurcher, P., 1874

BOOKS REVIEWED AND ADDITIONS TO THE LIBRARY

Numbers refer to pages

Active Carbon, J. W. Hassler, 431A
Alberta, Research Council, 31st Annual Report, 1950, 375A
Analysis, Instrumental Methods of, H. H. Willard, L. L. Merritt, and J. A. Dean, 168A
API Standards, 526A
API Standards Supplements and Bulletins, 168A
Applied Chemistry, Developments in, Symposium, 524A
ASTM Manual on Measurements and Sampling of Petroleum and Petroleum Products, 292A
ASTM Manual on Quality Control of Materials, 293A
ASTM Proceedings, 1950, 375A
ASTM Standards in Petroleum Products and Lubricants, 60A
ASTM Standards on Bituminous Materials for Highway Construction, Waterproofing and Roofing, 292A
ASTM Standards on Gaseous Fuels, 526A
ASTM Standards, Supplements, 1950, 292A, 375A
Automatic Control, Fundamental Methods, G. H. Farington, 558A
Berechnung von Fraktionierkolonnen für Vielstoffgemische, Bruno Riediger, 594A
Bitumen in Athabasca Bituminous Sand, Components of, D. S. Pasternack and K. A. Clark, 375A
Bituminous Roads of North America. Research and Construction, A. R. Lee, 375A
British Petroleum Equipment, 559A
British Standards, 59A, 60A, 111A, 242A, 335A, 374A, 480A, 526A
Canada, Mining Laws of, A. Buisson, 11A
Canadian Mineral Industry in 1948, 111A
Chemical Formulary, The, Vol. IX, H. Bennett, 241A
Chemical Works Safety, Third Conference, Proceedings, 110A
Chemicals, British and Their Manufacturers, 168A
Creep of Metals, L. A. Rotherham, 479A
Diesel Engines, Horizontal, R. A. Collacott, 110A
Distillation Equibrilibrium Data, Ju Chin Chu, 336A
Distillation, Laboratory Fractional, T. P. Carney, 336A
Economics of United States and World Oil, E. Ospina-Racines, 55A
Empire Mining and Metallurgical Congress, 4th Proceedings, 526A
Erdöl, Mächte und Probleme, A. M. Stahmer, 58A
Financial Analysis of Thirty Oil Companies for 1950. Frederick G. Coqueron and Joseph E. Pogue, 374A
Fischer–Tropsch and Related Syntheses, Henry H. Storch, Norman Golumbic, and Robert B. Anderson, 595A
Friction and Lubrication of Solids, F. P. Bowden and D. Tabor, 56A
Fluid Flow, Some Aspects of, 523A
Fuel Research 1939 to 1946, 110A
Fuel, Technical Data on, H. M. Spiers, 58A
Fuels and Oils, Analysis Methods, J. R. Campbell, 526A
Geological Survey Board, Report of 1949, 111A
Geology, Principles of, J. Gilluly, A. C. Waters, and A. O. Woodford, 594A
Government Chemist, Report for Year Ended 31st March 1950, 110A
High Additive Content Oils, Symposium on, 59A
Hydrocarbons Boiling Below 350° F, Physical Constants of, Robert Matteson, 293A
Hydrocarbons, Non-Benzenoid, Chemistry of, B. T. Brooks, 372A
Hydrocarbons, Physical Chemistry of, Vol. 1, A. Farkas, 292A
I.C.I. Engineering Codes and Regulations, 168A
Lubrication, Physics of, H. R. Lang, 373A
Lubricating Oils and Engine Deposits, Properties of, C. A. Bouman, 58A
Mechanical Engineers, Institution of, Proceedings, 1949, 59A, 374A
Mechanical Engineers, Institution of, War Emergency Issues, 168A
Microbalances, Symposium, Report on, 242A
Mineralötechnicker, Hilfsbuch für, I. Bd, A. F. Orlicek and H. Pöll, 478A
Mineral Oils, Aspects of Constitution of, K. van Nes and H. A. van Western, 288A
Minería en Colombia, La, El Petroleo, 432A
Motor Oils and Engine Lubrication, Carl W. Georgi, 57A
Natural Gasoline Association of America, Proceedings, 29th Annual Convention, 59A

North America, Possible Petroleum Provinces of, M. W. Ball, A. A. Baker, G. V. Cohee, P. B. Whitney, and D. Ball, 477A
Oil and Gas Development and Production Covering 1949, Statistics of, 293A
Oil and Petroleum Year Book 1950, Walter E. Skinner, 59A
Oil and Petroleum Year Book 1951, Walter E. Skinner, 527A
Oilfield Exploration and Development. Vol I. Principles. Vol II. Practice, A. Beeby Thompson, 110A
Oil Geology, Practical, Dorsey Hager, 522A
Petroleum Facts and Figures, 374A
Petroleum Geology, Kenneth K. Landes, 522A
Petroleum Geology, E. N Tiratsoo, 373A, 432A
Petroleum-Ingenier, Der, H. Umstätter, 431A
Petroleum Production Engineering: Petroleum Production Economics, Lester Charles Uren, 56A
Petroleum Subsurface Engineering, Elements of, H. Vance, 242A
Petroleum Technology, Reviews of, 293A
Process Heat Transfer, D. Q. Kerr, 168A
Reagents, Organic, for Organic Analysis, 58A
Reservoir Engineering, Elements of, S. J. Pirson, 168A
Royal Dutch Petroleum Co., 1890 to 1950, 167A
SAE Handbook, 1951, 558A
Safety in Petroleum Refining and Related Industries, G. Armistead, 242A
Scientific Organizations, International, Directory of, 167A
Screw Threads, Gauging and Measuring, 527A
Standardization in the Chemical Field, Symposium, Report on, 242A
Storage of Petroleum Spirit, H. E. Watts, 558A
Surface Active Agents, A. M. Schwartz and J. W. Perry, 111A
Synthetic Petroleum, Coal Suitable for the Manufacture of, Preliminary Report, A. B. Dutt, P. K. Ghosh, G. N. Dutt, and K. D. Shukla, 375A
Tar and Its Products, Standard Methods of Testing, 374A
Technical Publications 1948, 294A
Turbine Oils, Symposium on, 59A
Viscosity, at High Rates of Shear, Symposium on the Methods of Measuring, 480A
Wells of Power, Olaf Caroe, 241A
White Mineral Oil and Petrolatum, E. Meyer, 288A
World Geography of Petroleum, W. E. Pratt and Dorothy Good, 290A

JOURNAL OF THE INSTITUTE OF PETROLEUM

Honorary Editor
F. H. GARNER, O.B.E., Ph.D., F.R.I.C., F.Inst.Pet.

Honorary Associate Editor
E. B. EVANS, M.Sc., Ph.D., F.R.I.C., F.Inst.Pet.

Editor
GEORGE SELL, F.Inst.Pet.

ABSTRACTS

VOLUME THIRTY-SEVEN
1951

Published by
THE INSTITUTE OF PETROLEUM
MANSON HOUSE,
26 PORTLAND PLACE,
LONDON, W.1.

ABSTRACTORS

W. H. Adams.
N. L. Angel.
A. R. W. Baddeley.
H. J. Bentley.
V. Biske.
E. Bowes.
Miss M. C. Brown.
G. A. Carter.
E. J. Charles.
A. Cluer.
S. E. Coomber.
W. H. Crouch.
A. Draycott.
H. C. Evans.
D. W. Fosbury.
C. A. Fothergill.
N. W. Gillam.
R. W. Grafton.
J. G. Hall.
D. Hammerton.
R. Hesketh.
G. D. Hobson.
A. J. Horan.
A. J. Hugill.
W. Husband.
D. F. Jacques.
E. K. Johnson.
Miss D. Kenyon.
O. Mackay.
Mrs U. May.
F. Morton.
R. E. Pegg.
Miss V. P. Pittman.
R. Robb.
T. Rogala.
J. Scott.
G. Sell.
R. B. Shearn.
C. F. Smith.
A. Stocks.
M. Swiss.
J. Tadayon.
R. G. Temple.
C. N. Thompson.
N. Thorpe.
E. N. Tiratsoo.
R. Tyler.
T. Tyler.
P. Vrba.
C. G. Wall.
L. Whitham.

JOURNALS ABSTRACTED DURING 1951

Abbreviated Title	*Journal*
Advancement of Science	Advancement of Science.
Aero. Engng Review	Aeronautical Engineering Review.
Aeroplane	Aeroplane.
Airc. Engng	Aircraft Engineering.
Airc. Prod.	Aircraft Production.
Aluminium (Hungary)	Aluminium (Hungary).
Amer. Dyestuff Rept.	American Dyestuff Reporter.
Anal. Chem.	Analytical Chemistry.
Analyst	Analyst.
Annals of appl. Biology	Annals of Applied Biology.
Ann. Rept. Res. Council Alberta	Annual Report of the Research Council of Alberta.
Appl. Scientific Research (Holland)	Applied Scientific Research (Holland).
ASTM Bull.	ASTM Bulletin.
Australian J. Appl. Sci.	Australian Journal of Applied Science.
Auto Engr	Automobile Engineer.
Auto Ind.	Automobile Industries.
Birm. Univ. Chem. Engr	Birmingham University Chemical Engineer.
Bitumen, Teere, Asphalte, Peche	Bitumen, Teere, Asphalt, Peche und Verwandte Stoffe.
Brit. J. Appl. Phys.	British Journal of Applied Physics.
Brit. J. Industr. Med.	British Journal of Industrial Medicine.
Brit. Med. J.	British Medical Journal.
Bull. Amer. Ass. Petrol. Geol.	Bulletin of the American Association of Petroleum Geologists.
Bull. Ass. franç. Tech. Pétrole	Bulletin de l'Association française du Techniciens du Pétrole.
Bull. Ass. Suisse Electr.	Bulletin de l'Association Suisse des Electriciens.
Bull. Chem. Soc. Japan	Bulletin of the Chemical Society of Japan.
Bull. Geol. Soc. Amer.	Bulletin of the Geological Society of America.
Bull. Geol. Surv. Kansas	Bulletin of the Geological Survey of Kansas.
Bull. Schweiz Elektrotech.	Bulletin Schweizerischer Elektrotechnischer Berein.
Bull. Technique Ass. Ing. Bruxelles	Bulletin Technique de l'Association des Ingénieurs Sorties de l'Université de Bruxelles.
Bur. Stand. J. Res., Wash.	United States Bureau of Standards Journal of Research, Washington.
Calif. J. Mines & Geology	California Journal of Mines and Geology.
Canad. J. Tech.	Canadian Journal of Technology.
Canad. Min. metall. Bull.	Bulletin of the Canadian Institute of Mining and Metallurgy.
Chem. & Ind.	Chemistry and Industry.
Chem. Education	Journal of Chemical Education.
Chem. Engng	Chemical Engineering.
Chem. Engng & Min. Rev. (Australia)	Chemical Engineering and Mining Review (Australia).
Chem. Engng Prog.	Chemical Engineering Progress.
Chem. Ind. Wk.	Chemical Industries Week.
Chem. Prod.	Chemical Products.
Chim. Anal.	Chimie Analytique.
Chim. e Industria	La Chimica e l'Industria.
Chim. et Ind.	La Chimie et l'Industrie.
Conveyancer and Property Owner	Conveyancer and Property Owner.
Corrosion	Corrosion.
Doklad. Akad. Nauk S.S.S.R.	Dokladii Akademii Nauk S.S.S.R.
Electr. Times	Electrical Times.
Engineer	Engineer.
Erdöl u. Kohle	Erdöl und Kohle.
Faraday Soc. Discussions	Discussions of the Faraday Society.
Flight	Flight.
Fuel	Fuel.
Fluid Handling	Fluid Handling.

Abbreviated Title	*Journal*
Fueloil & Oil Heat	Fueloil and Oil Heating.
Gas Oil Pwr	Gas Oil Power
Geophysics	Geophysics.
Heating and Ventilating	Heating and Ventilating.
Hungarian J. Chem.	Hungarian Journal of Chemistry.
Industrial Bulletin	Industrial Bulletin.
Industr. Chem.	Industrial Chemistry.
Industr. Engng Chem.	Industrial and Engineering Chemistry.
India Rubber J.	India Rubber Journal.
India Rubber World	India Rubber World.
Ingenieur	De Ingenieur.
Institute Spokesman	Institute Spokesman.
I.P. Review	Institute of Petroleum Review.
Izvest. Akad. Nauk S.S.S.R.	Izvestia Akademii Nauk S.S.S.R.
J. Aero Sci.	Journal of Aeronautical Sciences.
J. Amer. chem. Soc.	Journal of the American Chemical Society.
J. appl. Mech.	Journal of Applied Mechanics.
J. appl. Phys.	Journal of Applied Physics.
J. Chem. Metall. Soc. S. Africa	Journal of the Chemical and Metallurgical Society of South Africa.
J. Chem. Soc.	Journal of the Chemical Society.
J. Coll. Sci.	Journal of Colloid Science.
J. Econ. Ent.	Journal of Economic Entomology.
J. Electrochem. Soc.	Journal of the Electrochemical Society.
J. Inst. Cert. Engrs, S. Africa	Journal of the Instn Certified Engineers, South Africa.
J. Inst. Fuel	Journal of the Institute of Fuel.
J. Inst. Heating & Ventilating Engrs	Journal of the Institute of Heating and Ventilating Engineers.
J. Inst. mar. Engrs	Journal of the Institute of Marine Engineers.
J. Inst. Petrol.	Journal of the Institute of Petroleum.
J. Iron & Steel Inst.	Journal of the Iron and Steel Institute.
J. Hungarian Chem. Soc.	Journal of the Hungarian Chemical Society.
J. Oil Col. Chem. Assoc.	Journal of the Oil and Colour Chemist's Association.
J. Palæont.	Journal of Palæontology.
J. Pharm & Pharmacology	Journal of Pharmacy and Pharmacology.
J. Phys. & Colloid Chem.	Journal of Physical and Colloid Chemistry.
J. Roy. Aero Soc.	Journal of the Royal Aeronautical Society.
J. Roy. Soc. Arts.	Journal of the Royal Society of Arts.
J. sci. Instrum.	Journal of Scientific Instruments.
King's Highway	King's Highway.
Laboratory	The Laboratory.
Lubr. Engng	Lubrication Engineering.
Mech. Engng	Mechanical Engineering.
Mech. World	Mechanical World.
Midwest Engr	Midwest Engineer.
Mikrobiologiya	Mikrobiologiya.
Mod. Plastics	Modern Plastics
Motor Ship	Motor Ship.
Museums J.	Museums Journal.
Nafta	Nafta.
Nature	Nature.
New Engl. J. Med.	New England Journal of Medicine.
New Zealand J. Sci. Tech.	New Zealand Journal of Science and Technology.
Official Digest	Official Digest.
Oil Forum	Oil Forum.
Oil Gas J.	Oil and Gas Journal.
Paint Manfr	Paint Manufacturer.
Paint Technol.	Paint Technology.
Petroleum	Petroleum.
Petrol. Engr	Petroleum Engineer.
Petrol. Process.	Petroleum Processing.
Petrol. Tech.	Journal of Petroleum Technology.
Petrol. Times	Petroleum Times.
Pipe Line News	Pipe Line News.
Proc. Roy. Soc.	Proceedings of the Royal Society.

Abbreviated Title	*Journal*
Producer's Monthly	Producer's Monthly.
Public Roads	Public Roads.
Rds and Rd Constr.	Roads and Road Construction.
Rds and Streets	Roads and Streets.
Rec. Trav. Chem. Pays Bas	Recouil des Travaux Chemiques des Pays Bas.
Refiner	Petroleum Refiner.
Research Council of Alberta Rep.	Research Council of Alberta Report.
Rev. Inst. franç. Pétrole	Revue de l'Institut Française du Pétrole et Annales des Combustibles Liquides.
Rev. Pétrolière	La Revue Pétrolière.
Rev. sci. Instrum.	Review of Scientific Instruments.
Riv. Comb.	Rivista Combustibili.
S.A.E. Trans.	Transactions of the Society of Automotive Engineers.
Schweiz Arch. Ang. Wise. Tech.	Schweizer Archiv für Angewandte Wissenschaft und Technik.
Scientific Lubrication	Scientific Lubrication.
Soap	Soap.
Soap Sanitary Chem.	Soap and Sanitary Chemicals.
Summary Op. Calif. Oilfields	Summary of Operations of California Oilfields.
Svensk Sjörfarts Tidning	Svensk Sjörfarts Tidning.
Times Rev. Ind.	Times Review of Industry.
Trans. Faraday Soc.	Transactions of the Faraday Society.
Trans. Inst. chem. Engrs	Transactions of the Institute of Chemical Engineers.
Trans. Inst. mar. Engrs	Transactions of the Institute of Marine Engineers.
Trans Instrum & Measurements Conf. Stockholm	Transactions of the Instruments and Measurements Conference, Stockholm.
Trans S. African Inst. Civil Engrs.	Transactions of the South African Institute of Civil Engineers.
Trans. Roy. Soc. Canada	Transactions of the Royal Society of Canada.
U.S. Bur. Mines Inf. Circ.	U.S. Bureau of Mines Information Circular.
U.S. Bur. Mines Rep. Invest.	United States Bureau of Mines, Report of Investigations.
Voodr. Koninklijk Inst van Ingenieurs (Holland).	Voordrachten Gehouden vor het Koninklijk Institut van Ingenieurs.
World Oil	World Oil.
World Petrol.	World Petroleum.

THE INSTITUTE OF PETROLEUM

NOTICES, DECEMBER 1951

ENTRANCE FEES AND SUBSCRIPTIONS

The current Entrance Fees and Annual Subscriptions for membership of the Institute are :

	Entrance Fee	*Annual Subscription*
	£ s. d.	£ s. d.
Members and Fellows	2 2 0	4 4 0
Associate Members and Associate Fellows .	1 1 0	3 3 0
Student Members	Nil	1 1 0

APPLICATIONS FOR MEMBERSHIP OR TRANSFER

The following have applied for admission to or transfer of membership in the Institute. In accordance with the By-laws, the proposals will not be considered until the lapse of at least one month after the publication of this *Journal*, during which time any Fellow, Member, Associate Fellow, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of the candidate.

The object of this information is to assist the Council in grading the candidate according to the class of membership.

The name of candidates' proposers and seconders are given in parentheses.

Application for Membership

BRACEY, Alan William, laboratory tester, " Shell " Refining & Marketing Co. Ltd. (*N. E. Jones ; D. Rawlinson.*)

BURCHETT, Bryan John, trainee, Messrs. Huxley & Co. (*W. H. Huxley ; G. Sell.*)

BUTCHER, John Leonard, plant operator, Iraq Petroleum Co. Ltd. (*E. G. Hannah ; I. D. Wardrop.*)

CLARK, John Durham, chemical engineer, The Bahrein Petroleum Co. Ltd. (*H. G. Russell ; K. S. Lennie.*)

CRAIG, William, oil chemist, Northern Aluminium Co. Ltd. (*A. Osborn ; E. R. Blane.*)

CROXTON, Frank Cutshaw, assistant director, Battelle Memorial Institute. (*G. H. Thornley ; C. D. Brewer.*)

FITZGERALD, William, technical representative, (Lubricants Dept.), Shell-Mex & B.P. Ltd. (*I. W. Evans ; E. J. Labrum.*)

GERMAN, William Richard, business manager, W. L. German & Co.

GOULD, Arthur William, works chemist, South-East Gas Board. (*A. J. Goodfellow ; D. S. Hill.*)

GURNEY, Charles Ernest, assistant manager, Shell-Mex & B.P. Ltd. (*A. J. Foster ; G. L. Coles.*)

HANLON-LLOYD, Graham, student, Birmingham University. (*F. H. Garner ; F. Morton.*)

HASHIMOTO, Saka, Chief of Petroleum Section, Nippon Mining Co. Ltd. (*H. Burstin ; H. K. Whalley.*)

HOOG, Han, associate director, Koninklijke/Shell Laboratorium. (*N. G. R. Karlbom ; G. H. Visser.*)

KENT, Anthony John, assistant driller, Anglo-Iranian Oil Co. Ltd. (*W. W. Evans ; P. T. Cox.*)

PLANT, Gordon Vickers, structural engineer, Manchester Oil Refinery Ltd. (*J. C. Wood-Mallock ; H. Kaye.*)

RICHARDS, Hugh Francis Gruffydd, fuel technologist, Vacuum Oil Co. Ltd. (*R. W. L. Fox; G. R. Nixon.*)

ROLLINSON, Hugh Alexander, student, Birmingham University. (*F. H. Garner; F. Morton.*)

SNASHALL, Hunter Maurice, technical assistant, Shell-Mex & B.P. Ltd (*T. W. Mathias; G. L. Coles.*)

STACH, Leopold William, private technical consultant, petroleum and natural gas development (Far Eastern Countries).

STEEL, George Frederick, supervisor (Bitumen Department), Shell-Mex & B.P. Ltd. (*E. A. Horwood; J. R. Thomson.*)

TURNBULL, Charles Brian, student, Birmingham University. (*F. H. Garner; F. Morton.*)

Transfers

HUTCHISON, Stanley John, chemical engineer, Trinidad Leaseholds Ltd. (*F. Morton; F. H. Garner.*) (*Student to Associate Fellow.*)

HYNE, Bertram George, chemical engineer, Bahrein Petroleum Co. Ltd. (*N. E. Watson; W. T. Barrett.*) (*Student to Associate Fellow.*)

JENNER, Peter, laboratory tester, "Shell" Refining & Marketing Co. Ltd. (*P. G. Higgs; G. W. Dorrell.*) (*Student to Associate Member.*)

SELWOOD, Peter, petroleum engineer, Iraq Petroleum Co. Ltd. (*A. H. R. Grimsey; J. W. Boyd.*) (*Student to Associate Member.*)

NEW MEMBERS

The following elections have been made by the Council in accordance with the By-laws.

Elections are subject to confirmation in accordance with the By-laws.

As Fellows

BRACKENBURY, J. M.
DAVIES, H. M.
EDWARDS, F. D.
MORRISON, D. M.

Transferred from Associate Member to Fellow

THOMPSON, A. W.

As Associate Fellows

BOVES, L.-E.
BROWNE, L. W.
BUKHARI, M. S.
CROMWELL, O.
DABELL, K. H.
DURHAM, J. S.
EL-KAREH, G.
FERRIDAY–PEARSON, J. E.
GORDON, P.
HAYES, R. J.
HOLNESS, H. C.
JONES, W. A.
KAMAR, G. C.
KANETKAR, A. G.
MCCORMACK, A. E.
MACNEISH, T. S.
MATHESON, A.
OFFER, L. D.
THOMPSON, F. L.
THOMSON, A. P.
WILLIAMSON, G. S.
WILSON, R. C.

Transferred from Student to Associate Fellow

CHURCHFIELD, S. E.

As Associate Members

LUGTON, J. M.
MACKINTOSH, A. J. D.
SIMPKINS, W. C.
STEDMAN, B. J.

As Students

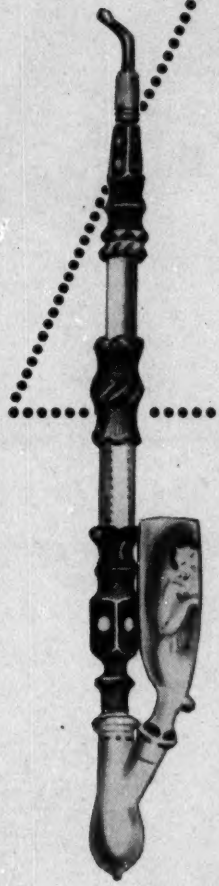
BROWNLOW, R. D.
RICHARDS, G. M.
STEPHENSON, I. C.

As Collective Member

INSTITUTE OF WEIGHTS AND MEASURES

NUMBER SEVEN

TALKING OF PIPES



from "The Pipe Book"
by Alfred Dunhill

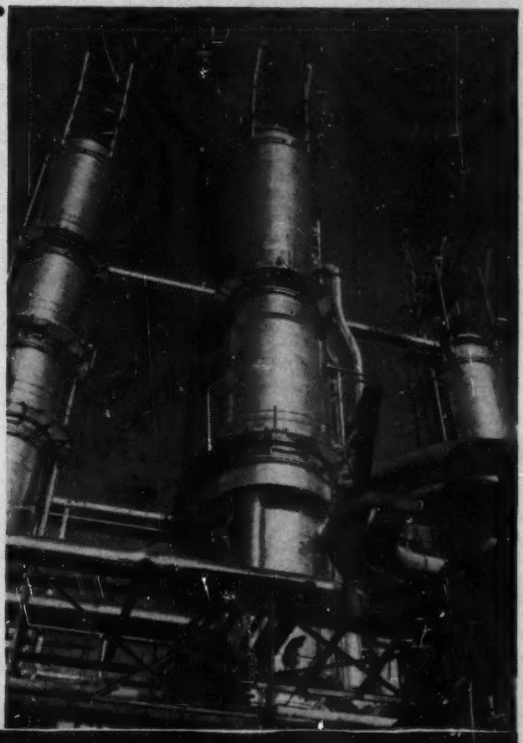
GERMAN PORCELAIN PIPE

The typical Central European pipe of today can be traced to the eighteenth century Dutch clay. The stem is, however, broken short and the bowl is inserted into a holder or base. By this arrangement, both bowl and stem are upright and the deleterious tobacco juices drain down into the holder. Such a pipe is capable of infinite variations in decoration.

INDUSTRIAL PIPING AND ITS HEAT INSULATION

Kenyon make a speciality of furnishing and applying heat insulation for oil refineries and petroleum chemical plants throughout the world. A complete service is offered including technical guidance and supervision on site at all stages of erection and production. Our engineers are available for consultation at all times.

WILLIAM KENYON & SONS LIMITED
DUKINFIELD - - - CHESHIRE



"A Shell Photograph"

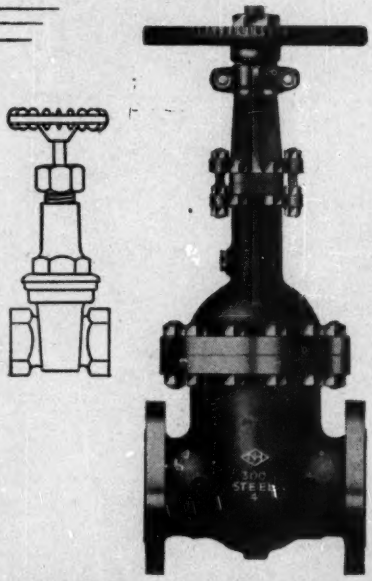
KENYON *Planned* HEAT INSULATION

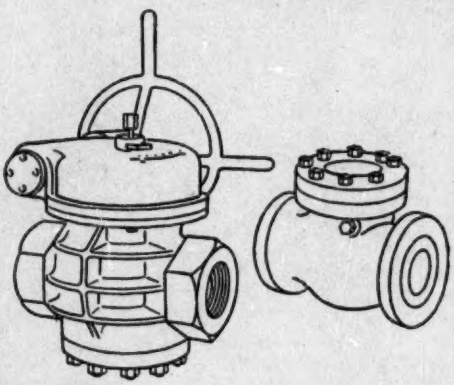
KH 117

Kindly mention this Journal when communicating with Advertisers

Valves and fittings

Designed & Developed for Oilfield Efficiency

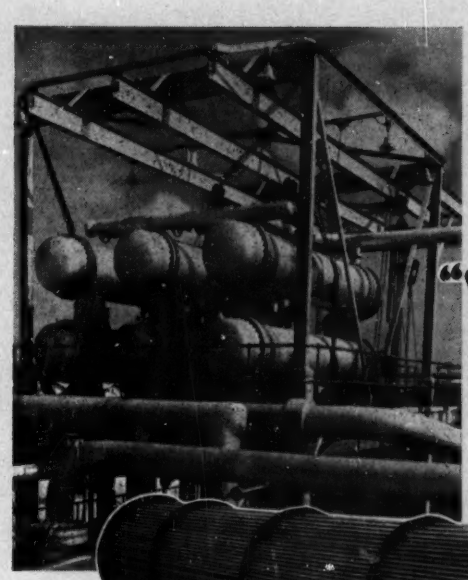




Our range of specialised productions for the Oil Industry includes CAST and FORGED STEEL, CAST IRON and BRONZE Gate, stop and Check Valves for all pressures and temperatures, for water, steam, oil, air and gas services.

Newman, Hender & Co. Ltd

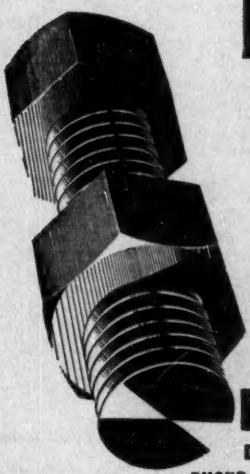
WOODCHESTER GLOS. ENGLAND

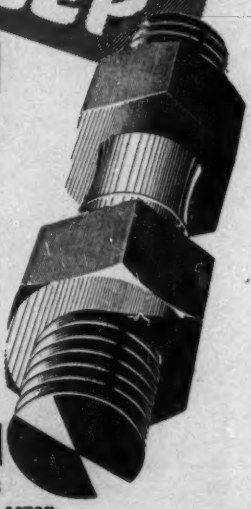


"Yorcalbro"
TUBES
FOR
HEAT
EXCHANGERS
AND
CONDENSERS

The
YORKSHIRE COPPER WORKS
LIMITED
LEEDS BARRHEAD, SCOTLAND

Eliminate "CREEP"
WITH
Marwin





HIGH TEMPERATURE "CREEP" RESISTING STUDS, BOLTS, NUTS AND SPECIAL PARTS

A positive defence against the effects of heat, these "Marwin" Products resist "creep" at elevated temperatures, resist embrittlement from exposures to high temperature stresses and at the same time retain high tensile strength at elevated temperatures. Write for details.

W. MARTIN WINN LTD
DARLASTON S. STAFFS
PHONE: DARLASTON 72/3/4. GRAMS: ACCURACY DARLASTON

MILLENNIUM KEY

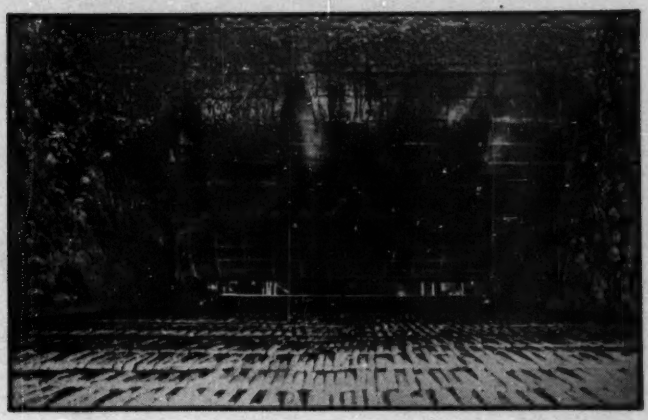
Millennium-Key
Cast Steel Fittings

(FOR OIL REFINERY & CHEMICAL PLANTS)

for Strength & Pressure Tightness

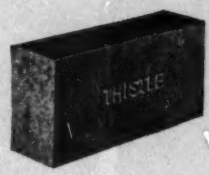
Lake & Elliot Ltd.
BRAINTREE ENGLAND

STEIN *Refractories*



For long and reliable service under arduous conditions "Nettle" and "Thistle" Firebricks are widely renowned.

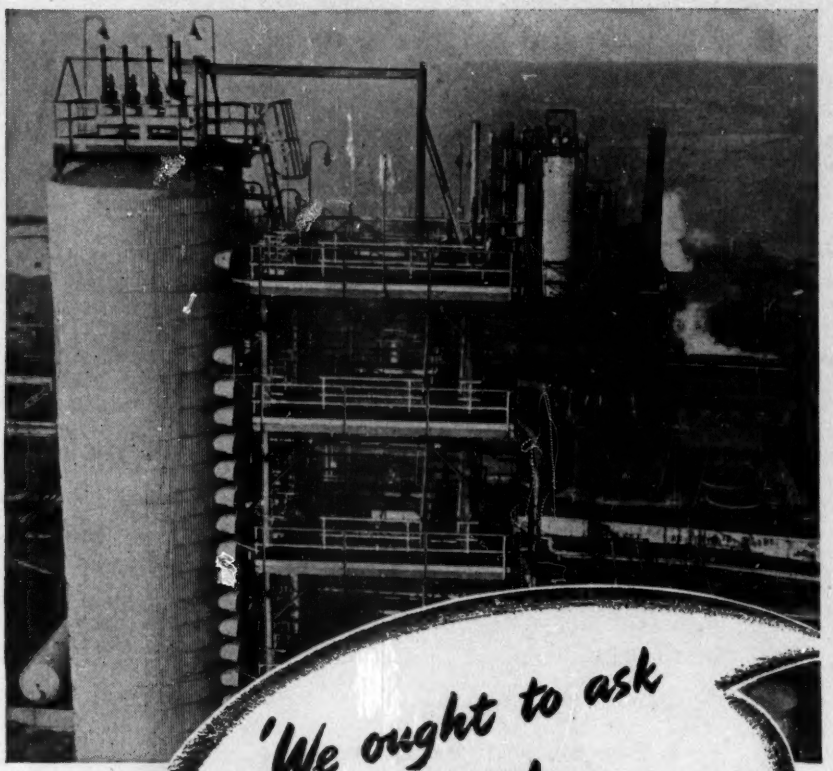
Made from selected fireclays by most modern methods under constant laboratory control "Nettle" and "Thistle" have set a standard for consistency of quality.



Full particulars of our Firebrick Brands, Refractory Cements, Castables and Concretes will be gladly sent on request.

JOHN G. STEIN & Co LTD Bonnybridge. Scotland

★ *Benches A and B Distillation Plant of the National Oil Refineries Limited at Llandarcy, South Wales, where the throughput is 80,000 barrels per day. Lincoln arc-welding again, of course.*



'We ought to ask Lincoln before we decide'

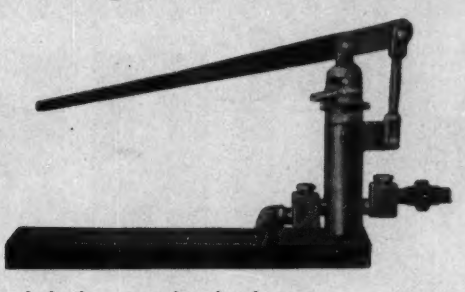
LINCOLN

World's largest manufacturers of arc-welding equipment and electrodes

LINCOLN ELECTRIC CO LTD · WELWYN GARDEN CITY · HERTS · WELWYN GARDEN 920

SM126

BAKER Hydraulic HAND PUMP



THIS rugged, light-weight, high-pressure pump originally was developed for removing cores from the Baker Cable Tool Core Barrel, and hundreds now are in use around the world for specialized service.

OTHER USES DISCOVERED—Operators have found that the Baker Hydraulic Hand Pump (Product No. 540) has dozens of other uses in both field and shop for all types of testing where a sturdy, efficient, simply constructed, readily portable hand pump is desired; for removing plungers from insert liner oil well pumps; for testing valves, fittings, tubing and casing; for setting Baker Cement Retainers when mud pumps or cement pumps are not available; for actuating hydraulically operated blow-out preventers; and for many other purposes.

It eliminates the necessity for purchasing expensive and elaborate machines ordinarily sold for testing purposes; and is ideal for use either as a low-pressure or high-pressure unit, completely self-contained and readily portable.

RUGGEDLY MADE AND EASY TO OPERATE—The Baker Hydraulic Hand Pump is a manually operated two-stage force pump having two pistons, one for development of low pressures (up to 2,000 psi) and the other piston for the development of high pressures (up to 6,000 psi).

Additional details will be found in the Baker (or Composite) Catalogue.
Prices and deliveries can be secured from :

BAKER OIL TOOLS, INC.

Box 2274 Terminal Annex, Los Angeles 54, California, U.S.A.

Another Practical and Dependable
BAKER *Product*

MONK

OF

WARRINGTON & LONDON

are organised and equipped
to carry out

CIVIL ENGINEERING
REINFORCED CONCRETE
& BUILDING CONSTRUCTION

connected with

THE OIL INDUSTRY

This organisation has been responsible for the construction of many major projects at Home and Overseas

A. MONK & COMPANY LIMITED

Head Office:	*London Office:*
Padgate, Warrington	*75 Victoria Street, S.W.1*
Tel: Warrington 2381	*Tel: Abbey 2651*

⊗117.66

Kindly mention this Journal when communicating with Advertisers

—— Oil fire risks ——

of the greatest magnitude

fully protected with

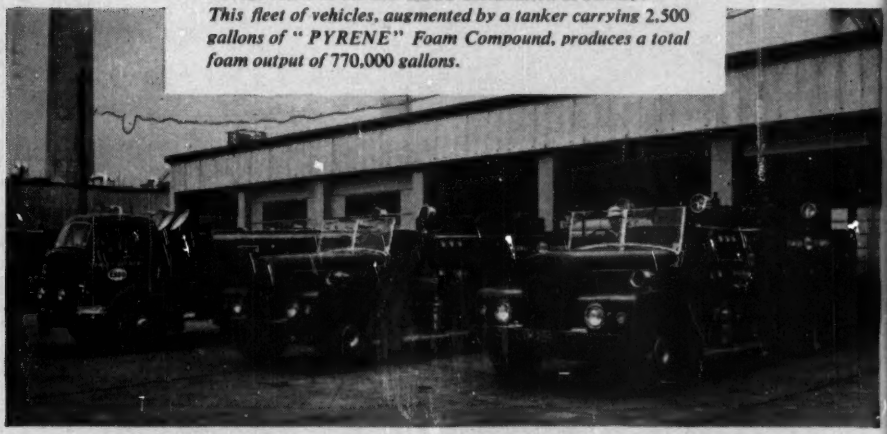
Pyrene TRADE MARK FIRE FIGHTING EQUIPMENT

So great are the recent developments in the production of "PYRENE" Foam Fire Fighting Equipment for extinguishing bulk oil and spirit fires that complete protection for all refineries and tank installations may be insured whatever the extent of their area or capacity. The latest "PYRENE" Foam Equipment includes: (*a*) A range of Mechanical Foam Generators and branch-pipes capable of delivering up to 2,400 gallons of Foam per minute. (*b*) Telescopic Foam Columns and various other forms of Portable Foam Appliances. (*c*) "PYRENE" Motor Driven Tenders capable of producing a Foam output of up to 6,400 gallons per minute, which may be used in conjunction with fixed Foam Risers and Inlets.

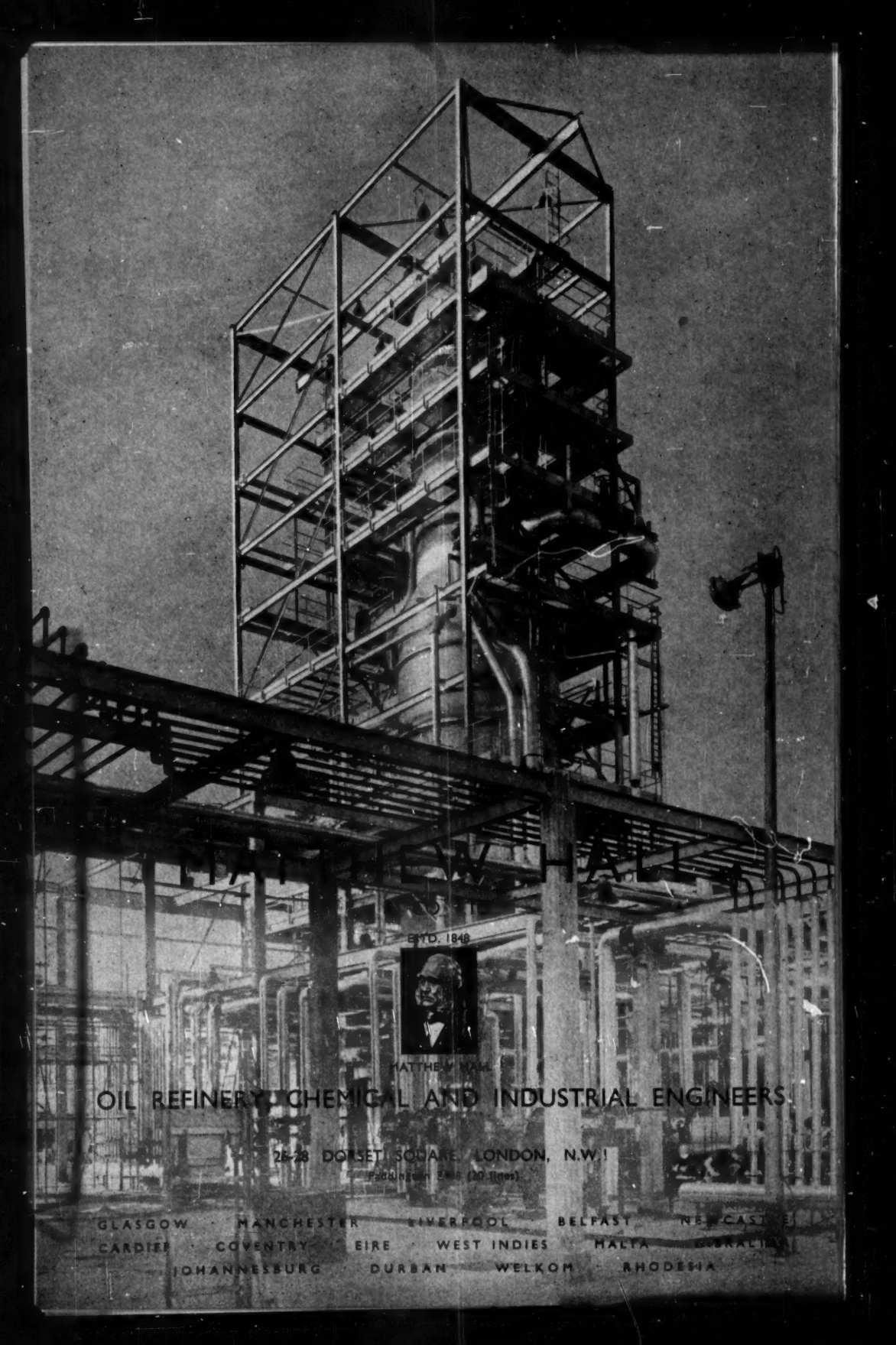
There is practically no limit to the volume of Foam which can be produced with "PYRENE" Foam Fire Fighting Equipment provided that ample water supplies are available.

Illustrated literature, specifications and, where desired, free impartial advice will be given on request. *Please write to Dept* J.L.P.12.

Below is shown a fleet of three "PYRENE" Foam Tenders which provide mobile fire protection for the refinery and storage tanks at the new ESSO Installation at Fawley. This fleet of vehicles, augmented by a tanker carrying 2,500 *gallons of "PYRENE" Foam Compound, produces a total foam output of* 770,000 *gallons.*



THE PYRENE COMPANY LTD. 9 Grosvenor Gardens, London, S.W.1. Telephone: VICtoria 3401


EST'D. 1848
MATTHEW HALL
OIL REFINERY, CHEMICAL AND INDUSTRIAL ENGINEERS
26-28 DORSET SQUARE, LONDON, N.W.1
GLASGOW · MANCHESTER · LIVERPOOL · BELFAST · NEWCASTLE
CARDIFF · COVENTRY · EIRE · WEST INDIES · MALTA · GIBRALTAR
JOHANNESBURG · DURBAN · WELKOM · RHODESIA

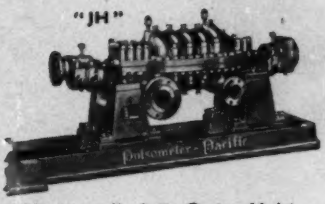
Pulsometer-Pacific

PUMPS FOR THE OIL INDUSTRY

"HV"

Vertically Split Casing Single-Stage Hot Oil Pumps.

"JH"



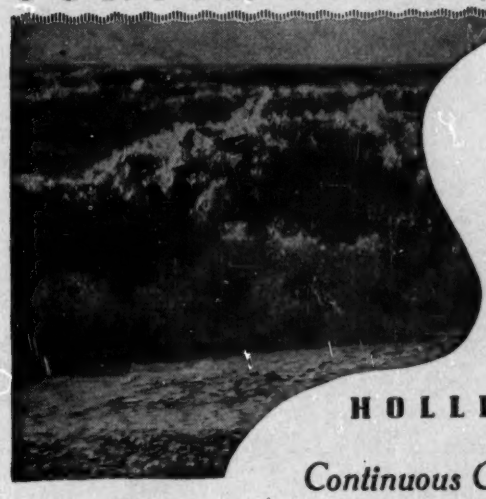
Horizontally Split Casing Multi-Stage Pumps for Hot Oil.

The above are some only of the Designs included.

Established 1875 Advertisement No. 3316

Pulsometer Engineering Co. Ltd.,
Nine Elms Ironworks, Reading.
ENGLAND

CONTINUOUS WASHING



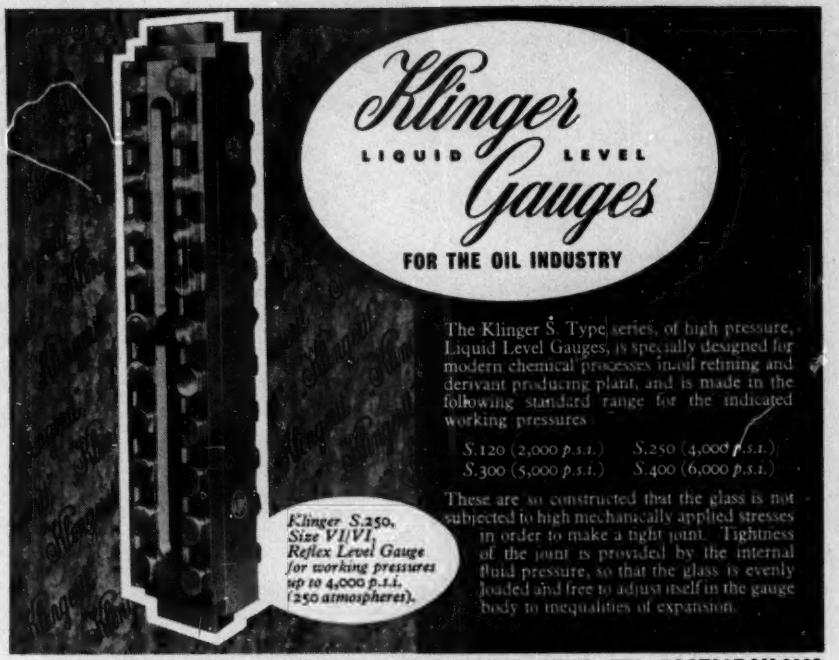
Holley Mott Plants are efficiently and continuously washing millions of gallons of Petroleum products daily. Designed for any capacity. May we submit schemes to suit your needs?

HOLLEY (H M) MOTT

Continuous Counter-Current Plant

Telegrams:
"Typhagitor, Fen, London."
Telephone: Royal 7371/2.

World-Wide Licensees. **H.M. CONTINUOUS PLANT LTD.**
FOUR LLOYDS AVENUE, LONDON, E.C.3.


Klinger
LIQUID LEVEL
Gauges
FOR THE OIL INDUSTRY
The Klinger S. Type series, of high pressure, Liquid Level Gauges, is specially designed for modern chemical processes in oil refining and derivant producing plant, and is made in the following standard range for the indicated working pressures
S.120 (2,000 p.s.i.)
S.250 (4,000 p.s.i.)
S.300 (5,000 p.s.i.)
S.400 (6,000 p.s.i.)
These are so constructed that the glass is not subjected to high mechanically applied stresses in order to make a tight joint. Tightness of the joint is provided by the internal fluid pressure, so that the glass is evenly loaded and free to adjust itself in the gauge body to inequalities of expansion.
Klinger S.250, Size VI[VI] Reflex Level Gauge for working pressures up to 4,000 p.s.i. (250 atmospheres).

RICHARD KLINGER LTD. KLINGERIT WORKS, SIDCUP, KENT. TEL: FOOTSCRAY 3022

LONDON OFFICE: BURWOOD HOUSE, CAXTON STREET, LONDON, S.W.1 TEL. ABBey 3021

NICEROL

FATAL TO FIRES

Here is a foam compound that will kill any oil or petrol fire with speed and certainty. Nicerol is a concentrate, producing a heavy-type foam of closely knit small bubbles which form a tough vapour-tight blanket over any surface of burning oil or petrol. It is characteristic of Nicerol Foam that it flows with the fire and is highly resistant to flash-back or re-ignition. It can be used successfully in any type of mechanical foam or air-foam apparatus—is equally effective with ***salt*** water or ***fresh*** and can be stored for years without deterioration.

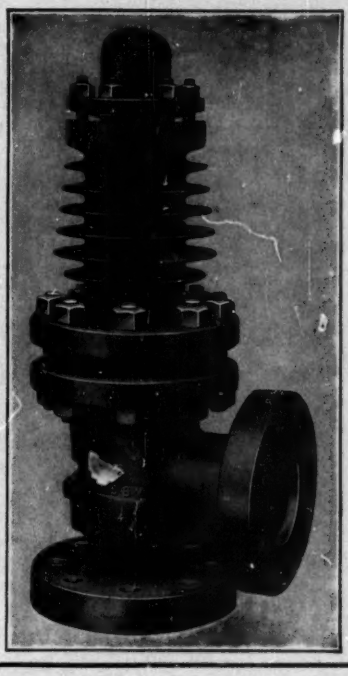
★ **The Royal Navy and the Royal Air Force use it and so do Oil Companies, Fire Equipment Manufacturers, Civil Air Lines, several Commonwealth and Foreign Government departments, and Fire Brigades throughout the world. What better recommendation ?**

★ **Nicerol is supplied in new heavy gauge steel drums specially designed to permit quick release and clean pouring of contents. These are supplied in 2, 5 or 40 Imperial Gallons capacity. 3 gallons of Nicerol will produce over 1,000 gallons of pure white foam.**

NICEROL LIMITED

Lisburn (Telephone: 2027 Telegrams: Nicerol, Lisburn) **N. Ireland**

Associated with the Burnhouse Organisation



CROSBY

RELIEF VALVES

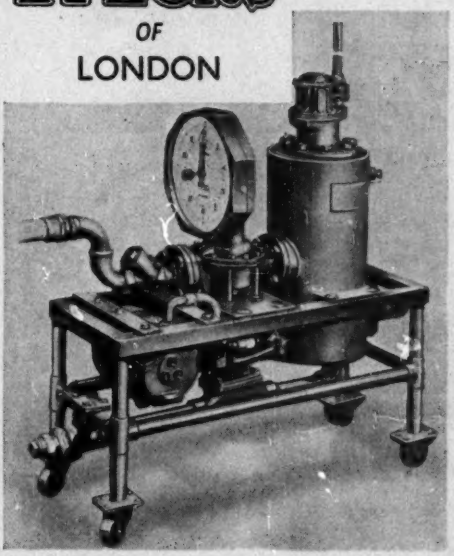
FOR OIL REFINERY SERVICE

FOR ALL PRESSURES UP TO 2,700 LBS.
TEMPERATURES UP TO 1,000° F.

MASONEILAN
AUTOMATIC CONTROLS
FOR LEVEL, PRESSURE, ETC.

CROSBY VALVE & ENGINEERING CO. LTD.
251, EALING ROAD, WEMBLEY

TYLORS
OF
LONDON



MANUFACTURERS
OF
METERS
FOR
PETROLEUM PRODUCTS

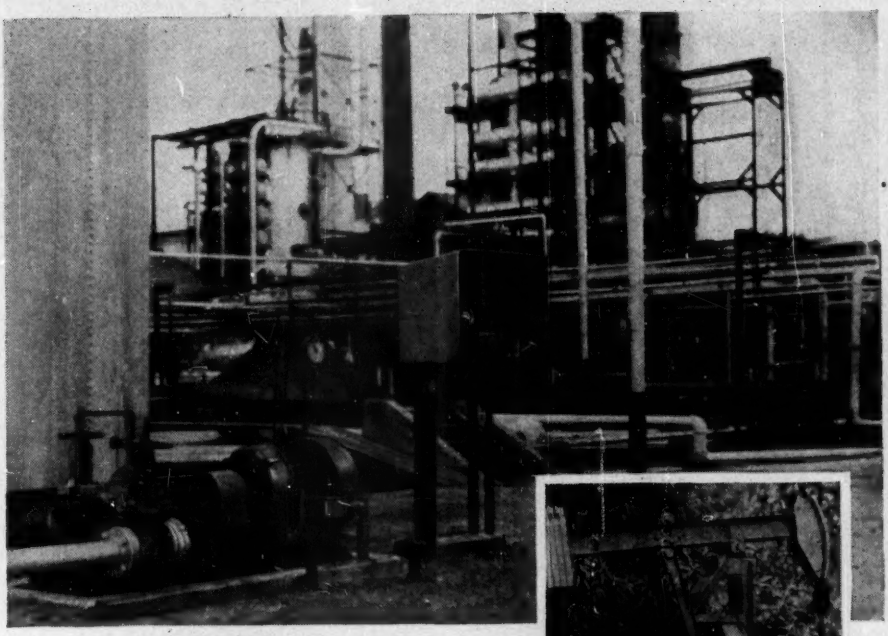
Tylor bulk petrol meter is approved by the Board of Trade (Standards Dept.)

FLOW CONTROL PROBLEMS OUR SPECIALITY

Illustration shows Motor-driven portable Unit with Air Elimination Device.

HEAD OFFICE AND WORKS:
BELLE ISLE
LONDON, N.7

Motors for the oil industry



More than 1,000 in the U.K.
750 — the Middle East
720 — the West Indies
500 — South America

More than 3,000 Metrovick motors have been supplied to the oil industry, including major installations abroad in Iran, Iraq, Venezuela, the West Indies and in the United Kingdom at Fawley, Grangemouth, Llandarcy and Stanlow. Further machines are on order for the new refineries at Coryton, Isle of Grain (Kent) and the Fawley and Llandarcy extensions.

A large number of well pump motors have been supplied to oilfields abroad and at home, and a complete drill rig barge for Maracaibo, Venezuela, is under construction. The photographs show typical applications of M-V motors in the refinery and field.

Member of the A.E.I. group of companies

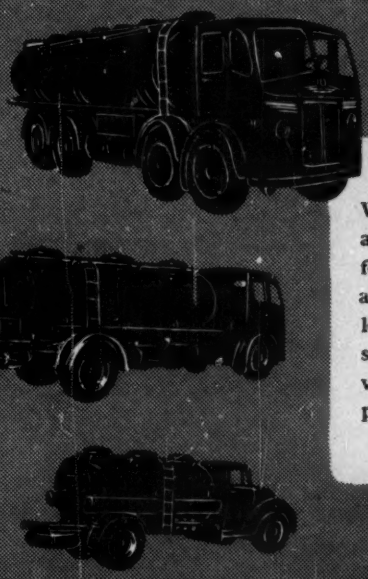
METROPOLITAN-VICKERS ELECTRICAL CO., LTD., MANCHESTER 17., ENGLAND

METROVICK *flameproof and weatherproof motors for refinery and field*

ROAD TANKS

TO TRANSPORT

SPIRIT
FUEL OILS
LUBRICANTS

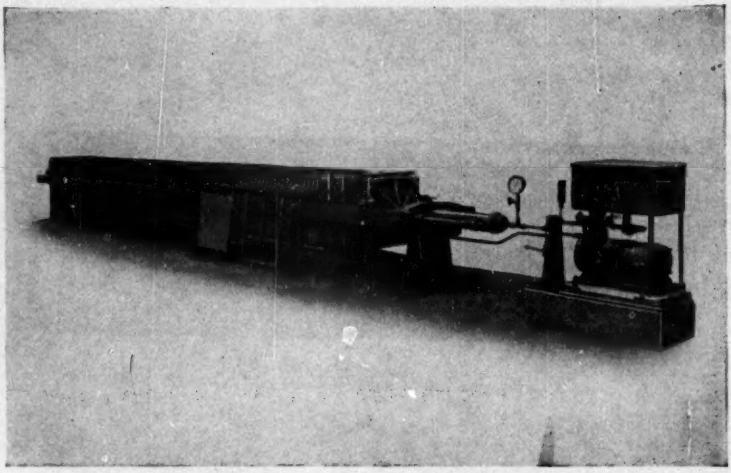


WHETHER the load is highly volatile spirit or viscous oil, it's a job for a Butterfield Road Tank. Size and design are suited to the payload and skilled fabrication ensures safe, economical working over very long periods. It certainly pays to specify BUTTERFIELD.

Butterfields

W. P. BUTTERFIELD LTD.
SHIPLEY, YORKSHIRE.
Tel. 52244 (7 Lines)

WAX MOULDING PRESSES



The above press has 100 mould frames giving 200 cakes 24" × 12" × 1¼".
Fitted with hydraulic closing gear.

OUR wide and long experience in the manufacture of wax moulding presses makes us specially suited to meet the most varied demands. May we submit proposals to suit your requirements?

A. F. CRAIG & CO. LTD.

CALEDONIA ENGINEERING WORKS

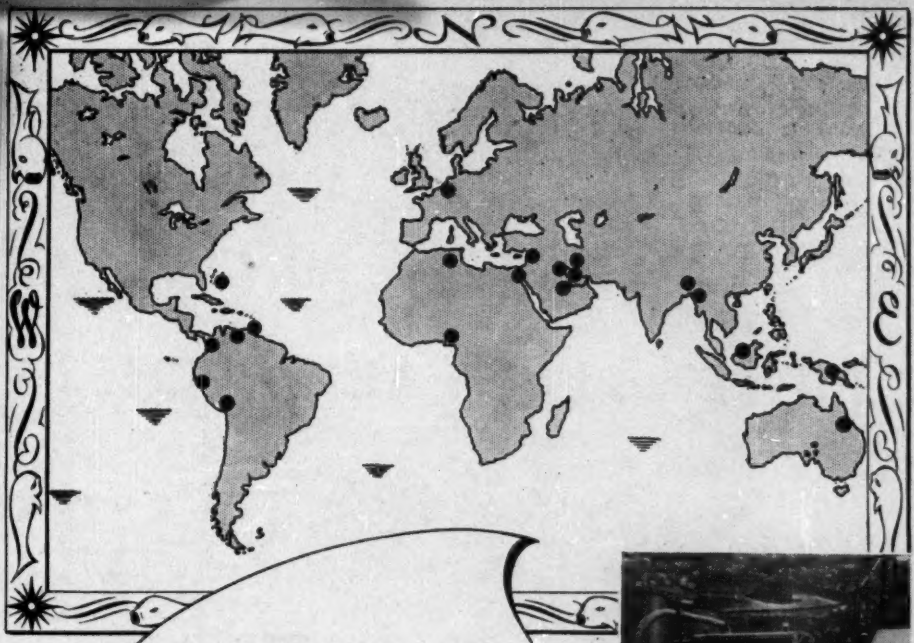
PAISLEY • SCOTLAND

London Office: 727 Salisbury House, London, E.C.2

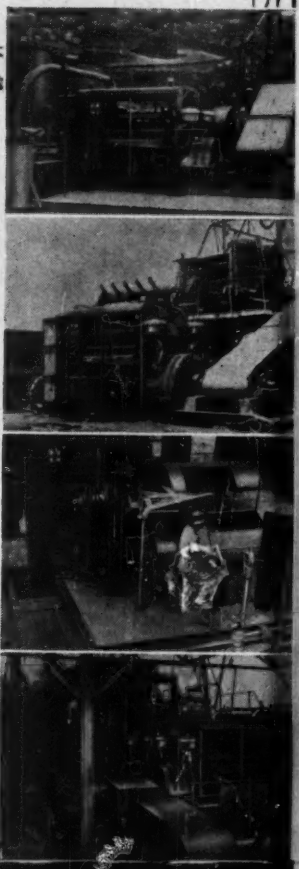
Telephone: MONarch 4756

American Associates:

THE KOCH ENGINEERING COMPANY, INC., WICHITA, KANSAS



These Oilfields use—



PAXMAN

OIL WELL DRILLING UNITS

from 90 - 725 B.H.P.

ILLUSTRATED ARE PAXMAN-ENGINED UNITS DRIVING SLUSH PUMPS AND DRILLING RIGS IN ARABIA, COLOMBIA, PERU, and SARAWAK

DAVEY, PAXMAN & CO. LTD., COLCHESTER

(ASSOCIATED WITH RUSTON & HORNSBY LTD., LINCOLN)

WEIR

The foremost name in

BOILER FEED PUMPS

and

POWER PLANT AUXILIARIES

for more than sixty years

G. & J. WEIR LTD.
CATHCART · GLASGOW

FEED PUMPS · FEED HEATERS · DE-AERATORS · EVAPORATING & DISTILLING PLANTS · REGENERATIVE CONDENSERS · and HEAT EXCHANGERS

PIPE LINE *Protection*

Thousands of tons of "Bitumastic" 70 B Enamel have been used to protect gas and oil pipe lines in America and the Middle East. Its outstanding anti-corrosive properties have been demonstrated on pipe lines all over the World.

"BITUMASTIC" REGISTERED TRADE MARK 70B ENAMEL

FULL PARTICULARS ON REQUEST

WAILES DOVE BITUMASTIC LTD • HEBBURN • CO. DURHAM

AGENTS THROUGHOUT THE WORLD

Kindly mention this Journal when communicating with Advertisers

Glitsch

TRUSS-TYPE

BUBBLE TRAYS

Economical processing and extreme flexibility have made these bubble trays the choice of refiners throughout the world. The Glitsch truss-type design saves time and money in both erection and operation. Longer runs "on stream" are made possible and maintenance is greatly simplified.

Covered by British patents 606,318, 606,870, 615,228, 625,418, 628,311, 628,343, 629,141.

METAL PROPELLERS LTD

Stainless Steel Specialists

74 PURLEY WAY, CROYDON, SURREY

Telephone: Thornton Heath 3611 Telegrams: Metaprops, Souphone, London

C.M.14

EDECO

THE STANDARD RANGE includes

TYPE VHW for extremely hard and abrasive formations to overcome excessive Gauge wear.

JET TYPE BITS with special circulation nozzles for increasing the rate of penetration in soft formations.

FOR SPEED AND STRAIGHT HOLE

ROCK BITS

THE EDECO ROCK BIT is manufactured by English Steel Corporation Limited in conjunction with the English Drilling Equipment Co. Ltd. The EDECO Bit has been designed, engineered, built and tested by a team of American experts who have specialised in building Rock Bits.

English Steel Corporation have the facilities for making any known high grade steel, and the S.A.E. Steel used in the EDECO ROCK BIT is identical with that used by the American Rock Bit makers.

All the processes from the selection of the materials through all the stages of forging, machining, welding and heat treatment are carried through inside the English Steel Corporation Plant.

There is, therefore, full assurance that the EDECO ROCK BIT is made of the finest materials and under the supervision of experts at every stage.

ENGLISH DRILLING EQUIPMENT

Unique

"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method.

G. P. Newall & Co., Ltd.

POSSILPARK GLASGOW · N

Kindly mention this Journal when communicating with Advertisers

THE "OILWELL" No. 76 RIG

for Medium Drilling Depths of 6,000 to 10,000 ft.

IT'S LIGHT IN WEIGHT
. . . with capacities far beyond most rigs of comparable size and weight.

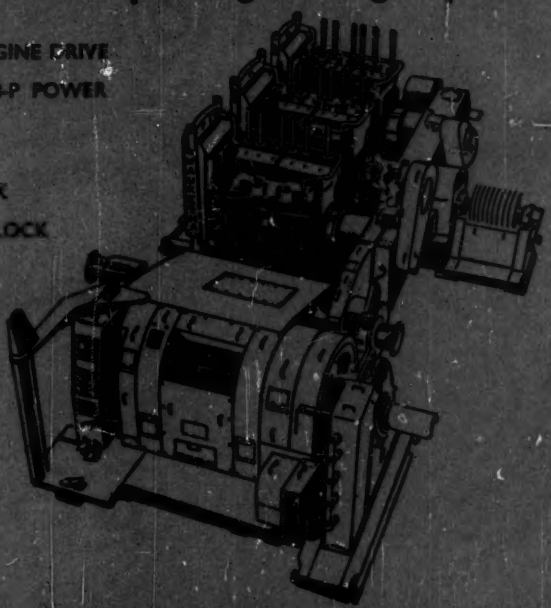
IT'S COMPACT
. . . with unitized assemblies and oiltight, weatherproof construction throughout.

IT'S EASY TO MOVE
. . . either with the compound or disconnected from it.

HIGHLY FLEXIBLE COMPOUND
. . . for 2 or 3 engines with 1 or 2 pump drives, makes it suitable for a wide range of applications. Can also be furnished with hydraulic torque converters or couplings.

The following "Oilwell" Companion Equipment is Engineered for Corresponding Drilling Depths:

- No. 700 . . . 2- OR 3-ENGINE DRIVE
- No. 214-P AND No. 218-P POWER SLUSH PUMPS
- No. 56-300 SWIVEL
- No. 480 CROWN BLOCK
- No. 400 TRAVELLING BLOCK
- 20½-INCH OILBATH ROTARY
- BRANTLY HYDRAULIC FEED CONTROL WITH AUTOMATIC REGULATOR



Whether you need a complete drilling rig or only a single item remember "OILWELL" is a good place to buy all your oil-field equipment and supplies.

OIL WELL SUPPLY COMPANY

Incorporated in U.S.A. with Limited Liability

5 QUEEN STREET, LONDON, E.C.4

with Representatives to Serve All Oil Fields

USS "OILWELL"

UNITED STATES STEEL